ESTIMATION OF POSTHARVEST LOSSES AND ANALYSIS OF INSECTICIDE RESIDUES IN SOME SELECTED VEGETABLE CROPS IN THE GREATER ACCRA REGION OF GHANA

BY

JEMIMA NAA AMERLEY AMARTEY
(10195765)

THIS THESIS IS SUBMITTED TO THE UNIVERSITY OF GHANA, LEGON IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE AWARD OF MASTER OF PHILOSOPHY DEGREE IN CROP SCIENCE

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DECLARATION

I Jemima Naa Amerley Amartey declare that except of references cited, which have been duly acknowledged, this work "ESTIMATION OF POSTHARVEST LOSSES AND ANALYSIS OF INSECTICIDE RESIDUES IN SOME SELECTED VEGETABLE CROPS IN THE GREATER ACCRA REGION OF GHANA" is the result of my own research as a student of the Department of Crop Science, College of Agriculture and Consumer Sciences, University of Ghana during the 2011-2012 academic year. This work has never been presented in whole or part for the award of any degree of this University or elsewhere.

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JEMIMA NAA AMERLEY AMARTEY

This thesis has been submitted for examination with our approval as supervisors

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PROF. D. OBENG-OFORI

....

PROF. D. BRUCE SARPONG

DEDICATION

I would like to dedicate this book to my father Mr. Nicholas Amartey, my mother Mrs. Comfort Amartey and sister Lydia Amartey for their prayers, encouragement and financial support

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I want to give thanks to God Almighty for his infinite grace, wisdom, direction, and abundant blessings in life entire endeavour.

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God richly bless you and provide for all your needs.

ABSTRACT

Small-scale farmers in the Greater Accra region of Ghana grow vegetable crops including tomato, cabbage, pepper, okra and garden eggs and apply many types of pesticides to control pests and diseases that attack these crops. This study was conducted in the Accra Metropolitan District, Adenta Municipal District, Ashaiman Municipal District, Dangme West District, Ga South Municipal District and Ga West Municipal District. The purpose of the study was to estimate the postharvest losses in the seleted vegetable crops incurred by the farmers and retail traders, determine pesticide use pattern of vegetable farmers and analyse specifically, the level of insecticide residues in okra sent to the market. The communities studied included Weija, Kojo Ashong, Kordeabe, Dawenya, Dzorwulu, Obaakruwa, Ashaiman, Atomic, Okushiabade and Onyaasanaa. A total of 100 farmers and 75 retailers were randomly selected for the studies. The various methods used for the study included questionnaire administration, physical observations and personal interviews. The vegetable farmers and traders were interviewed and both closed and open ended questionnaires were administered to them from November 2011 – March 2012 to assess the extent of postharvest loss and pesticide use pattern of the farmers. Okra samples from four farms namely Weija, Dawenya, Atomic and Ashaiman were sent to the Ghana Standard Authority for analysis of insecticide residues. It was confirmed that postharvest losses was a major problem experienced by vegetable crop farmers and traders. The losses were mostly caused by pests and diseases and poor handling. As a result farmers sprayed chemical pesticides to control them in order to meet market demands. From the study, percent estimated losses by farmers were 13% for cabbage and okra, 12% for pepper, 1% for eggplant, and 20% for tomato. About 15%, 7%, 8% and 10% were estimated lossess for cabbage, pepper and okra respectively. Loss for garden eggs was insignificant due to their ability to maintain their freshness till they were sold to consumers. Commonly applied insecticides included Auntie Ataa, Golan, Cydim Super, Attack; fungicides included Sulpur 80, Bendazim, Mangozeb and herbicides were Round up, Ejumawura and Paraquat. Only 5% of 100 farmers interviewed used neem extracts to control pests and diseases. Most farmers' sprayed pesticides themselves but 10% employed skilled labour and the pesticide application was usually done in the mornings or evenings. Knowledge on the correct pesticide application was obtained from Ministry of Food and Agriculture staffs, pesticide dealers and colleague farmers. The farmers also attested to the fact that the chemical pesticides used were poisonous and caused various health hazards. Some compounds detected from the test conducted in the laboratory indicated the presence of Alpha-Endosulfan, Endrin, Fenvalerate, P,P'-DDE and Ethoprophos. The results generated indicated that the okra samples that were tested for insecticide residues were below EU's Minimum Residue Levels (MRLs).

LIST OF ABBREVIATIONS

ECD	Electron Capture Detector
EFSA	European Food Safety Authority
EPA	Environmental Protection Agency
EU	European Union
FAO	Food and Agriculture Organisation
FAOSTAT	FAO Statistics
FRE	Fully Registered Pesticides
GC	Gas Chromatograph
GCAP	Ghana Commercial Agriculture Project
GDP	Gross Domestic Product
GEPC	Ghana Export Promotion Council
GSA	Ghana Standards Authority
ISSER	Institute of Statistical Social and Economic Research
JMPR	Joint Experts Meeting on Pesticide Residue
MoFA	Ministry of Food and Agriculture
MRL	Minimum Residue Level
NPAS	Northern Presbyterian Agricultural Services
OCs	Organochlorines
OPs	Organophosphates
PCL	Provisionally Cleared Pesticides
PFPD	Pulse Flame Photometric Detector

PPRSD	Plant Protection and Regulatory Services Directorate
SP	Synthetic Pyretroids
SPSS	Statistical Package for Social Science
SRID	Statistics, Research and Information Directorate
WCA	West and Central Africa
WHO	World Health Organisation

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CHAPTER ONE

1.0 INTRODUCTION

1.1 BACKGROUND OF STUDY

World vegetable production is a very economically important agricultural activity and a major component in the diet of people throughout the world. The major producers of vegetable crops in the world are China, India and the United States with China being the largest producer. Altogether, the world vegetable crop production is 965,650,533 metric tons (FAO Statistics, 2010).

Agriculture contributed to 25.6% of GDP in 2011; however, it remains the dominant sector of the Ghanaian economy and the highest contributor to the nations GDP employing about 60% of the country's labour force (ISSER, 2011).

In Accra, there are about 800-1000 vegetable crop farmers of whom 60% produce exotic and 40% indigenous local or traditional vegetable crops (Obuobie *et al.*, 2006). Some of the exotic crops cultivated are lettuce, cabbage, cucumber, spring onions, and cauliflower while the more traditional crops are tomatoes *(Lycopersicon esculentum*), okro *(Abelmoschus esculentus)*, local spinach *(Amaranthus spp)*, garden eggs (aubergine) *(Solanum melongena)*, onion *(Allium cepa)*, shallots *(Allium escalonicum)*, sweet and chilli pepper *(Capsicum annuum)*and hot pepper *(C. frutescens)* (Obuobie *et al.*, 2006).

Worldwide, vegetable crops have been recognized as an important part of diet acting as sources of vitamins and minerals and also provide bulk of food preventing constipation. Apart from production of vegetables for local consumption, they also serve as major component of the Ghana non-traditional export commodities, generating foreign exchange to the country. In 2011 foreign earnings received from non-traditional export was 2.3%. The volume of total non-traditional agricultural exports declined since 2007 from 16.9% to a low 10.1% in 2010 but increased to 12.3% in 2011. Ghana in 2011 received US$296.98 million from non-traditional agricultural exports as compared to US$164.96 million in 2010 (ISSER, 2011). Of the other minor vegetable exports, ravaya (baby aubergines) may offer some opportunity. Ghanaian exports of aubergines to Europe decreased from 106,213 kg in 2010 i.e. US$ 92,601 to 78,139 kg i.e. US$82,573 in 2011 (GEPA, 2012).

In developing countries, the losses of crops due to pests, plant diseases and competition from weeds are great. Crop losses of the order of 40-75% have been reported (Clarke *et al.*, 1997). Even more significant are postharvest losses which are due to a multitude of factors, particularly insects and rodents attacking stored products (Hogstedt, 1992). The use of pesticides in agriculture in tropical countries like Ghana has been instrumental in reducing crop loss both before and after harvest (Clarke *et al.*, 1997).

The use of pesticide has been traced by Historians to 1000 B.C. Pesticides are either chemicals or biological substances used to control pests (Waxman 1998), including insecticides, fungicides and herbicides. There are more than 30 categories of pesticides based on their chemical structure. The behaviour of pesticides in the agricultural produce is of great importance, since the disappearance, persistence, or partial transformations of such compounds determine their usefulness or their potential effects to the environment (Wang and Liu. 2000).

Although pesticides are often misunderstood to refer only to insecticides, the term pesticide also applies to herbicides, fungicides, acaricides and other substances used to control pest. Under the US law, a pesticide may also refer to any substance or mixture of substances intended for use as a plant regulator, defoliant or desiccant (Hurst *et al.*, 1991). According to Ghana's Act 528, a pesticide is defined as any substance, mixture of substances or other agents used to control, destroy or prevent damage or protect something from a pest. The definition also includes chemical substances that are used to attract and repel pests as well as those used to regulate plant growth or remove coat or leaves.

Since 1950, the use of pesticides has increased 50 fold and 2.5 million tons of industrial pesticides are now used annually (Farag *et al*., 2011). This is to be expected as food security issues particularly in developing countries are very high on the international agenda. Pests contribute significantly to food losses and the control of pests is very central to the attainment of food security at all spatial scales (Al-Eed *et al*., 2006; Iya and Kwaghe, 2007).

Pesticides are manufactured under very strict regulation processes to function with logical certainty and minimal impact on human health and the environment. However, serious concerns have been raised about health risks resulting from residues in food (Eskenazi *et al*., 2008; Damalas and Eleftherohorinos, 2011). By their very nature, most pesticides show a high degree of toxicity because they are intended to kill certain organisms and thus create some risks of harm (Zidan, 2009; Abdelgadirand and Adam, 2011). Within this framework, pesticide use has evoked grave concerns not only of potential effects on human health but also about impacts on wildlife and sensitive ecosystems (Power, 2010; Damalas and Eleftherohorinos, 2011). Also a study by Amoah *et. al.,* (2006) showed that microbiologic and pesticide contamination levels of vegetables in Ghanaian markets pose a threat to human health.

Pesticide use in Ghana has increased over the years and it is particularly high in high value cash crops and vegetable crop production systems with concomitant environmental and health effects. The Diamond Back Moth (DBM) in cabbage, Tomato Yellow Leaf Curl Virus (TYLCV) in tomato, and the shoot and fruit borers in garden egg are important biotic constraints for each of these crops. They are controlled with increasing levels of pesticides. According to experts, resistance has already developed in DBM against the main insecticides available in Ghana (Smale *et al.,* 2006).

Since these chemicals are potentially toxic and highly persistent, there is a pressing need for their control and monitoring in the environment. Monitoring pesticide usage and contamination in food commodities provide useful information on assessing food safety to consumers (Biney, 2001).

Currently, 10 pesticides have been banned in Ghana with international convention. The reasons for the ban are either the persistence of the pesticide in the environment or high toxicity (Gerken *et al.*, 2001).

1.1 Justification

Vegetable crops are an important source of plant nutrients, vitamins and minerals that are essential for human health and well being, particularly for children, pregnant and nursing women. Field observations have reported that 40% to 50% of vegetable crops produced are lost before they can be consumed, mainly due to high rates of bruising, pest and disease attack, water loss and subsequent decay during postharvest handling (Kitinoja, 2002, Ray and Ravi, 2005). In Accra, the capital city of Ghana for example, there are about 800-1,000 farmers engaged in commercial urban vegetable farming where the vegetable produced are eaten by more than 200,000 urban dwellers daily (Obuobie *et al*., 2006).

Post harvest losses result not only in the loss of the actual crop, but also losses in resources, labour needed to produce the crop and livelihood of individuals involved in the production process. For example when 30% of a harvest is lost, 30% of all the factors that contributed to producing the crop are also wasted (World Resources, 1998). The estimation of postharvest loss result in the identification of potential postharvest interventions that could address the problems and issues found in the various value chains and help to reduce losses and/or add value. A report by Egyir *et. al.*, (2008) stated that estimate of production losses in developing countries are hard to judge.

Agricultural productivity is however threatened by pests' infestations (Ruttan, 2005) and Ghana is no exception. Pesticides have been used to control crop pests and this has helped to increase crop yield and improve product quality (Cooper and Dobson, 2007). The use of pesticides in Ghana has increased over time and is elevated in the production of high value cash crops and vegetables (Gerken *et al.*, 2001)

Despite the glowing evidence of rampant use of pesticides in vegetable cultivation in Ghana there is little information on their residue status and national tolerance limits on vegetable and other food crops (Biney, 2001).

Since most pesticides are toxic in nature, their continuous ingestion by man even in trace amounts, can result in accumulation in body tissues with serious adverse effects on health (Handa *et. al.*, 1999). Due to this, most European countries have laid down regulations aimed at reducing the incidence of food poisoning. This includes the monitoring of the pesticide residues in food from field to the market. In Ghana not much work has been done to detect or quantify the amount of residue of pesticides in vegetable crops.

In developing countries such as Ghana, farmers face immense risks of exposure owing to the use of toxic chemicals that are banned or restricted in other countries (Al-Eed *et al*., 2006; Nasr *et al*., 2007; Adhikari, 2010). Wrong application techniques, badly maintained or totally unsuitable spraying equipment and inadequate storage practices exacerbate these risks (Al-Wabel *et al*., 2011). Often the re-use of old pesticide containers for food and water storage also contributes to the risk of exposure (Ecobichon, 2001; Damalas and Eleftherohorinos, 2011).

Research conducted in the past decade in Ghana and internationally point to the presence of pesticide residues in a number of food items including strawberries, onions, cucumber, lettuce, cabbage, okra, pepper, tomatoes, beans, oranges and lemons (Hussain *et al*., 2002; El-Nahhal, 2004; Hanson *et al*. 2007, Armah, 2011). Pesticide residues do not only constitute a possible danger to soil microfauna and microflora (Pal *et al*., 2006), their toxic effects on humans are manifest when bioaccumulation occurs along the food chain after initial plant uptake (Pal *et al*., 2006; Hanson *et al*., 2007; Al-Wabel *et al*., 2011).

It is important that the use of pesticides and chemical residue levels in vegetable crops are monitored on a continuous basis so that policy interventions can be developed for safer use of these pesticides.

1.2 OBJECTIVES

The aim of the study was to estimate the postharvest losses in some selected vegetable crops at the farmer and retail level and to analyze the insecticide residues in okra grown under pesticide application. Specifically, this study sought to:

- Estimate postharvest losses of some common vegetable crops grown in Ghana.
- Determine the pesticide use pattern of vegetable farms in the Greater Accra Region of Ghana.
- Assess the levels of insecticide residues in okra produced in the Accra Metropolis.

1.3 Organisation of Study

The study is organised into six sections. Section one is the Introduction, including the background and objectives of study. Section two is the literature review and Section three describes the scope of the study and methodology employed. Section four describes the results obtained from the survey. Section five discusses the findings based on the study objectives and Section six presents the recommendation for future studies.

CHAPTER TWO
LITERITURE REVIEW

2.0 Economic importance of vegetable crops

Vegetable crop production in urban, peri-urban and rural areas plays important roles in the socio-economic development of Ghana. It ensures food security, provides raw materials for local industries, and generates foreign exchange, employment and incomes for a section of the population (Nouhoheflin *et al.*, 2004; Obuobie *et al*., 2006). In the last 20 years, Ghana has developed a significant export of fresh produce to Europe. The European Union imported almost 90,000 tonnes of fresh produce from Ghana in 2007, which earned the Ghanaian horticulture cluster some €80mn (Jaeger *et al.*, 2008). Current volume and value of vegetables exported from Ghana in 2011 was 12,018,914kg and a USD value of 3,877,656 (GEPA, 2012).

2.1 Vegetable crop production in Ghana

The acreage farmed by small scale vegetable crop farmer's ranges between 1 to 2 acres or 0.4 to 0.8 ha while the acreage cropped in the dry season is usually very small, 0.25 acre or 0.1 ha. The vegetable crops most commonly grown in Ghana are: tomato, onion, shallots, okra, egg plant, local spinach, Indian or Gambian spinach, sweet and chilli pepper, hot pepper, lettuce, cucumber, cabbage, spring onions, and cauliflower, (Sinnadurai, 1973, Obuobie *et al.*, 2006). According to SRID projection, the area used for vegetable crop production in 2010 was 70,000Ha and the average yield of some selected vegetables such as tomato, garden egg and pepper under rainfed conditions were 7.5, 8.0 and 6.5 metric tons per ha, respectively (MoFA, 2011). Table 2.1 indicates the export volumes and values of cabbage, pepper, okra, tomatoes and garden eggs from 2003-2011.

Table 2.1: Volume and Value of Some Selected Vegetable Crops exported from Ghana (2003-2011)

YEAR	SELECTED VEGETABLE CROPS									
	CABBAGE		PEPPER		FRESH OKRA		TOMATOES		GARDEN EGGS	
	Weight kgs.	**Value US$**	**Weight Kgs.**	**Value US$**	**Weight Kgs.**	**Value US$**	**Weight Kgs.**	**Value US$**	**Weight Kgs.**	**Value US$**
2003	20,495	2,806	4,674.100	1,822,310	135,928	61,572	4,368,940	426,871	866,730	521,709
2004	xxx	Xxx	3,933.486	1,822,970	xxx	xxx	606,530	56,036	xxx	xxx
2005	1,774	1,429	1,365.360	731,410	xxx	xxx	xxx	Xxx	124,034	66,000
2006	xxx	Xxx	990,314	350,442	xxx	xxx	109,242	39,939	92,667	39,919
2007	167	5	1,578,055	622,219	xxx	xxx	6,228	15,367	92,373	33,991
2008	84	122	1,620,830	714,614	xxx	xxx	18,535	15,992	248,659	127,932
2009	60,110	35,617	951,905	470,148	xxx	xxx	43,872	9,774	57,349	46,783
2010	140,986	214,017	983,374	350,442	xxx	xxx	23,178	7,248	106,213	92,601
2011	42,239	171,238	1,002,710	1,184,964	xxx	xxx	13,397	103,833	78,139	82573

Source: Ghana Export Promotion Authority/ Data Processing Department, (2012)

xxx:-Not available

The agricultural sector in Ghana including vegetable crop production is saddled with many problems and difficulties. These can be considered as the main reason for low productivity in the sector. Poor roads and inadequate road networks are the main problem and this limits access to and from producing areas, resulting in low prices (lowermanya.ghanadistricts.gov.gh).

Another problem the producers of vegetable and fruit crops in Ghana face is the marketing of the produce (Obuobie *et al*., 2006). The problem of marketing is compounded by lack of storage facilities, especially for vegetable crops. Hence, farmers are compelled to sell at any price quoted by middlemen and women, whose activities appear to undermine the value of the farmers work (lowermanya.ghanadistricts.gov.gh).

Inadequate funds or capital, coupled with high input costs, usually pose a threat to agricultural activities in Ghana. These prevent farmers from having access to modern inputs, like tractors, improved seeds and the recommended chemicals, which would help them to engage in commercial or large-scale agriculture, resulting in an often low level of agriculture technology. Other problems affecting the agriculture sector is lack of irrigation and water storage facilities, land acquisition, pest and disease infestation, poor weather and soil fertility (lowermanya.ghanadistricts.gov.gh).

2.2.0 Cabbage (*Brassica oleracea var capitata*)

Its origin and centre of differentiation is thought to be in the west of the Mediterranean basin or in the Asia Minor (Romain, 2001). Although, it is a biennial, it is cultivated as an annual (Amoako, 2010). Cabbage, a member of the cruciferous family that includes broccoli, mustard, cauliflower, Brussels sprouts, kale, kohlrabi and bok choy, is thought to have been domesticated as a crop in the Mediterranean region of Europe (Baldwin, 1995). It was originally valued by ancient Romans and Greeks as a medicinal plant for the treatment of a variety of ailments including gout, headaches, and ingestion of poisonous mushrooms (Economic Research Service, 2002).

Cabbage has traditionally been used for medicinal purpose as well as for cooking. It has anti-inflammatory property and contains chemicals which can prevent cancer (Amoako, 2010). Traditionally, the Romans and Egyptians would drink cabbage juice before big dinners to prevent intoxication. Cabbage seeds are said to prevent hangovers (Norman and Shealy, 2007). According to Horna *et al.*, (2006), cabbage is popular both for commercial production and for home gardens. It is a popular vegetable grown and eaten in the urban and peri-urban areas of Ghana (particularly around Accra), where urban agriculture has boomed to meet a rising demand for fresh vegetable crops in the absence of appropriate refrigerating facilities.

FAO reports that the total world production of cabbage and other brassicas for 2011 was 68,584,199 metric tons (67,501,016 long tons; 75,601,138 short tons). The nations with the largest production were China, which produced 46 percent of the world total, and India, which produced 12 percent. Top 5 producing countries were: China (31,750,000 metric tons), India (7,949,000 metric tons), Russia (3,527,620 metric tons), South Korea (3,049,333 metric tons) and Ukraine (2,004,000 metric tons) (FAO, 2011).

While it is an economic alternative for migrants and fills a gap for urban consumers, cabbage production also brings negative environmental and health externalities mainly related to high pesticide and water use (Horna *et al.*, 2007). Oxyllus, KK cross, Drumhead, Japanese Hybrid Cabbage, Suttons Tropical, Marion Market and Golden Acre are some varieties of cabbage suitable for production in Ghana (Obeng-Ofori *et al.*, 2007).

2.2.1 Diseases of cabbage

Some of the most common diseases that affect cabbage are listed below:

2.2.1.1 Damping Off - This soil-borne fungus Rhizoctonia root rot (*Rhizoctonia solani*) commonly affects seeds and young transplants. Infected seeds decay in the soil, while young seedlings and transplants rot at the soil level (Obeng-Ofori *et al.*, 2007).

2.2.1.2 Downy Mildew (*Peronospora paresitica*) - This fungal disease, attacks both seedlings and mature plants. Infected plants develop a gray mold on the underside of the leaf. The leaf top first turns yellow and then brown. Eventually, the leaves wither and die, thus killing the plant (Obeng-Ofori *et al.*, 2007).

2.2.1.3 Black Rot - Black rot, caused by the bacterium *Xanthomonas campestris* pv. *campestris*, is one of the most destructive diseases of cabbage and other crucifers. Chlorotic discoloration on leaves, which turn to dark brown or black. Black discoloration of the vascular bundles and internal tissue break down. (MoFA, 2011).

2.2.1.4 Bacteria soft rot (*Erwinia carotovora)* is a major disease of cabbage. It attacks the leaves of cabbage and affected areas take on a water-soaked appearance and start to decay, emitting an unpleasant smell. Cabbage heads decay rapidly and turn dark (MoFA, 2011).

2.2.1.5 Viruses - The most common virus affecting cabbage, are *Turnip mosiac virus,'* and *Cauliflower mosiac virus*. Affected plants develop black spots, causing stunted plant growth (Doubrava *et al.*, 2004).

2.2.2 Pests of Cabbage

The major pests of cabbage and the damage they cause are described in table 2.2.

Table 2.2 Major Pests of Cabbage

Major pests	Comments
Diamond-back moth (DBM) (*Plutella xylostella)*	It is the most serious pest of cabbage. DBM female moth lays its eggs singly. Eggs are glued to the underside of leaves and hatch after 3-5 days into green larvae. Larvae creep to underside of leaf, pierce the epidermis and tunnel or bore through the leaf tissue. Progressively eat leaf from underneath leaving the upper cuticle intact creating a bizarre window, which later disintegrates.
Webworms or cabbage borer (*Hellula undulalis)*	The light brown larvae or caterpillars of the cabbage webworm bore into the main veins of the leaves of cabbages and later into the centre of the stems, where they then feed. This makes these pests very difficult to control with pesticides.
Cabbage aphids (*Brevicoryne brassicae)*	Usually occur in large numbers, mainly during dry spells. Sucking pests, grey or green with soft pear shaped bodies often in colonies on lower side of leaves. Suck sap causing stunting growth and honeydew excretes on leaves
Cutworm (*Agrotis sp)*	Dull coloured moths lay eggs in soil surface or on stems. Mature larvae hide during day and emerge at night to feed on crop causing damage by cutting young plant stems at the base and feeding on foliage. Larvae bend characteristically in an o-shaped when disturbed

2.3 Pepper

Pepper (*Capsicum annuum* L.) belongs to the Solanaceae family and it originated from South and Central America where it was domesticated around 7000 BC (Hunziker, 2001). The genus *Capsicum* includes 30 species, five of which are cultivated: *Capsicum annuum* L., C. *frutescens*, *C. chinense*, *C. pubescens* and *C. baccatum* (Wang and Bosland, 2006). Pepper has been cultivated basically for use as spice and vegetable crop for thousands of years (Andrews, 1995).

Pepper grows well in all parts of Ghana. *Capsicum* spp can be divided into four groups based on characteristics such as pungency (hotness), colour, shape, intended use and genetics. Hot pepper is known as Cayenne, Chilli, Tabasca, Bird's Eye or Red pepper (Obeng-Ofori *et al.*, 2007). In West Africa, hot pepper is a major vegetable crop and is an important constituent of local dishes. Sweet pepper, also known as bell pepper or Paprika are grown for consumption in the urban areas and also for export. Both hot pepper and sweet pepper are grown in Ghana (Obeng-Ofori *et. al.*, 2007).

FAO, (2007) reported that currently Ghana is producing about 279,000 metric tons. Ghanaian chili exports have ranged between 26,000 and 41,000 metric tons over the past 5 years. Exports increased about 60 percent from 2005 to 2007 since Legon 18 started being exported.

Varieties of pepper grown in Ghana include the bell type, Bird's eye, Legon 18, MI 2, Fresno and Jalapeno (Obeng-Ofori et al., 2007).

2.3.1 Diseases of pepper

2.3.1.1 Dumping off or stem and root rot caused by *Rhizoctonia, Fusarium solani and Pythium* spp are common nursery diseases, particularly severe during cool wet conditions. Affected seedlings rot at ground level and topple over. Seed decay may also occur. The disease can be controlled by (a) disinfecting seeds with appropriate fungicide (b) sterilization of seed bed for nursing of seeds (c) avoiding dense sowing in the nursery (d) provision of good soil drainage (e) watering should be done only when necessary and (f) practicing crop rotation (Obeng-Ofori et al., 2007).

2.3.1.2 Viral diseases in general cannot be treated with chemicals. Ensuring that seeds are free from any viral infection and adopting an effective management strategy to eliminate the insect vectors are useful to prevent infection. Prevention and control measures include the following (a) elimination of insect vectors (b) prompt removal and destruction on disease plants especially before fruit set (c) elimination of alternate weed hosts (d) planting of resistant variety if available (e) ensure balanced plant nutrition (f) peppers should not be planted next to tomatoes, cucumbers or sunflower fields (Obeng-Ofori *et al.*, 2007).

2.3.1.3 Leaf Spot (*Cercospora capsici*) Disease affects mainly leaves of pepper seedlings. Initial symptoms are small dark spots on leaves and these spots later enlarge to cover whole leaf, causing leaf to turn yellow and drop off. Fungicides can be used to control this disease (MoFA, 2011).

2.3.2 Pests of Pepper

Table 2.3: Some major pests of pepper in West Africa and the damage they cause

No.	Major Pests	Comments
1	Leaf beetle *(Lema* spp.)	Minor pests of localized importance. Both larvae and adults feed on young leaves and tips of shoots, causing minor defoliation. Chemical control is usually unnecessary.
2	Tomato fruitworm (*Helicoverpa) zea*)	Bores inside fruits. Chemical insecticides, *Bacillus thuringiensis*, and parasitic wasps are used to control this pest.
3	Cotton aphids (*Aphis gossypii Glover*)	Feed on the sap of leaves, causing the foliage to curl. Aphids also create a sugary substance that leads to black sooty mold growth on foliage. Aphids are controlled by the use of chemical insecticides, reflective mulches, and crop rotation.
4	Thrips (*Thrips* spp and *Frankliniella* spp)	Remove sap from foliage, causing midveins to dry and leaves to cup upwards. Thrips are managed by eliminating host weeds, rotating crops, and spraying insecticides.
5	Broad mites (*Polyhagotarsonemus latus*)	The tiny pests feed on the underside of leaves causing the foliage to become dry and brittle. Fruits may be scarred. Mites are managed by sowing tolerant varieties, eliminating host weeds, rotating crops, and spraying miticides.
6	Termites (*Odontotermes* spp)	They are polyphagous pest throughout tropical Africa. Isolated plants may be damaged by feeding on the bark causing a condition called ring-barking. Such plants are usually under water stress or those accidentally damaged by various agronomic practices. Chemical control is not usually necessary. Damaged plants should be uprooted and destroyed by burning.

2.4.0 Tomato (*Solanum lycopersicum*)

According to Orzolek *et al.*, (2006), tomatoes originated in South America—specifically in Peru, Bolivia, and Ecuador. Columbus and other explorers brought tomatoes to Europe by the late 1400s. In Europe and the United States, tomatoes were used only as ornamental plants until the early 1800s because the fruit was thought to be poisonous (Orzolek *et al.*, 2006).

Tomatoes are a member of the botanical family *Solanaceae*, which contains many potentially poisonous plants (nightshade, nicotianas [includes tobacco and petunias], Jimson weed [belladonna], and mandrake), as well as edible plants (potatoes, capsicums, and eggplants). All members of this family have toxic alkaloids present in either their leaves or their fruits (Orzolek *et al.*, 2006). Commercial tomato production did not begin until after 1860 when tomatoes were finally accepted by consumers. Since 1890, tomato breeding has developed varieties adopted for use around the world.

China is the largest producer, accounting for about one quarter of the global output, followed by United States and India. Tomato is a food security crop as it is the most consumed vegetable in Ghana. This crop is produced all over the country but the main producing areas are located in the Northern regions (Horna *et. al.*, 2007). It is also a fairly important cash crop in the outskirts of urban areas in the forest zone. A flourishing tomato production also occurs in the Greater Accra area and in the Akumadan and Wenchi districts in the Ashanti and Brong Ahafo regions, respectively (Obeng-Ofori *et al.*, 2007). Tomato demand, however, is higher than the supply and Ghana imports tomato at least 6 months of the year (Horna *et al.*, 2007).

2.4.1 Cultivars

Tomato cultivars are generally classified according to their growth habit, fruit shape, cultivation method (outdoor or green house production) and whether the fruit is a fresh market or a processing type. In Ghana, cultivars which have proven successful for cultivation in the Southern savannah areas include local types such as Fireball, Wosowoso, OK1, OK5, OK7-2, Improved Zuarungu, Marglobe, Victor and Pusa Early

Dwarf (Awuti, 1971; Blay, 1978). In the forest zone, successful cultivars include Dwarf Gem, Improved Zuarungu, Ife No.1, Local, MH6/1, Red Cloud, Ronita, Ace VF, etc. (Norman, 1992). Other promising cultivars widely grown in Ghana are Pectomet and Marmande.

2.4.2 Pest of Tomatoes

The major pests of tomato and the damage they cause are described in table 2.4.

Table 2.4: Major Pests of Tomato

Major pests	Comments
Aphids *(Aphis gossypii)*	Occasionally attack tomato heavily. Feed on the soft terminal shoots and on the underside of leaves. May also transmit virus disease during feeding. Honeydew produced by aphids' cause's unsightly black moulds on tomatoes which reduces their market value. Attacked plants may wilt and die
Fruit borers (American bollworms [*Helicoverpa armigera*] and leaf-eating caterpillars (cotton leafworms [*Spodoptera littoralis*])	Different kinds of caterpillars attack developing and mature fruits of tomato. The American bollworm comes in various colours. A single caterpillar can bore into m ay tomato fruits in one night. Fungi and bacteria enter these fruits through the holes and cause the fruits to rot and become worthless. The cotton leaf worm feeds on leaves of tomato and bores into the fruits, especially those lower down the plant.
Fruit fly (*Rhagoletis ochraspis*)	It is an important pest of tomato at the fruiting stage. It pierces fruits and leaves rotten spots. Adult fly pierces fruit to lay eggs inside. The small white maggots or larvae develop in the fruit and pupation occurs in the soil below the host plant.
Root-knot nematodes (*Meloidogyne spp.)*	Nematodes are one of the most important pests of tomato. These same species also attack egg plant, pepper, cabbage, carrot and other vegetables. They are microscopically small worms that live in the roots of their host and cause galls or root-knots. Some affected plants may show yellow leaves, poor growth and even wilting. Affected roots are short and have many swellings or galls. Plant become stunted and may die.
Tomato mirid bugs *(Cyrtopeltis teriuis)*	Adults and nymphs of slender, dark green mired bugs feed on tender terminal stems and flower stalks of tomato plants. Inject a toxic substance/saliva into the tissues, causing small, brown necrotic spots to develop. Adult female mirids pierce tomato stems to lay eggs resulting in major damage to stems.
White flies (*Bemisia tabaci*)	White fly adults are small, white, winged insects that fly off readily when disturbed. They attack tomatoes from seedling stage to maturity. White fly adults and nymphs occur under tomato leaves, sucking the sap and secreting sticky honeydew on which black mould develops. The adult transmit the leaf curl virus disease, which causes considerable damage to tomato plants.

2.4.3 Diseases of tomatoes

Tomatoes are infected by several diseases. They can get early or late blight, either white or grey mould (or both), and then they can have problems with diseases like curly top and corky root rot etc.

2.4.3.1 Wilts *(Fusarium oxysporum)* are caused by a soil-borne fungus that attacks the roots through small wounds (made during transplanting or resulting from nematode attack). Plant wilt from lower leaves and leaves turn yellow and die; later whole plant wilts and dies (MoFA, 2011).

2.4.3.2 Damping Off (*Pythium spp*) affects young, seemingly healthy seedlings that suddenly develop a dark lesion at the soil line, then quickly wilt and die. Cool, damp soil, overwatering, and overcrowding will increase probability of infection. The use of clean potting soil and germination trays and tools will reduce the incidence of the disease. Crowded seed beds should be avoided. Watering should be done carefully during the first two weeks after sprouting (Obeng-Ofori *et al.*, 2007).

2.4.3.3 Early (or dry) tomato blight (*Alternaria solani*) is a major disease during the rainy season. It is caused by a soil-borne and air borne fungus. Symptoms are brownish-black angular spots with concentric circles on the leaflets. Black or brown sunken lesions develop on stems and fruits (MoFA, 2011).

2.4.3.4 *Tobacco Mosaic Virus*: There are several closely related viruses (the tobamoviruses) that cause the wilted, mottled, and underdeveloped fern-like leaves characteristic of the tobacco mosaic virus. All are spread by mechanical means.

Sanitation is therefore of the utmost importance in reducing the incidence of the disease. Infected plants should be destroyed (Obeng-Ofori *et al.*, 2007).

2.4.3.5 Rots and cankers *(Phoma spp., Phomopsis spp.)* Rots and cankers are caused by fungi and bacteria that infect tomato stems and roots. Root and stem rot fungus is present in soil and attacks roots, causing collars to rot. The bacteria that attack plants cause blight and cankers of stems, leaves and fruits (MoFA, 2011)

2.4.3.6 Sun Scald: Sunscald occurs on green tomato fruit exposed to the sun. The initial symptom is a whitish, shiny area that appears blistered. The killed, bleached tissues gradually collapse, forming a slightly sunken area that may become pale yellowish and wrinkled as the fruit ripens. The killed tissue is quickly invaded by secondary organisms and the fruit decays (Gleason and Edmunds, 2006).

2.5.0 Okro

Okro *(Abelmoschus esculentus; syn. Hibiscus esculentus)* as the crop is known in West Africa, is also known as Okra (America) or Lady's Finger (British) (Obeng-Ofori *et al.,* 2007). Being native of tropical Africa, okra is the choicest fruit vegetable grown extensively in the tropical, subtropical and warm areas of the world like India, Turkey and Africa (Annonymous, 2004). In Ghana it is the fourth most popular vegetable after tomatoes, capsicum (peppers) and garden eggs. It is mainly produced for local consumption with a few farmers now producing for the export market in all the ecological zones (Tweneboah, 1998).

According to Anonymous (2004) the species apparently originated in the Ethiopian highlands, though the manner of distribution from there is undocumented. The Egyptians and Moors of the 12th and 13th centuries used the 18 Arab words for the plant, suggesting that it had come from the east. The plant may thus have been taken across the Red Sea or the Bab-el-Mandeb strait to the Arabian Peninsula, rather than north across the Sahara. In Africa, there is a great diversity in the crop. It is traditionally grown in the following countries: Ghana, Cote d'Ivoire, Nigeria, Egypt, Sudan, Burkina Faso, Togo, Cameroon, Tanzania, Zambia and Zimbabwe. The most important production countries are Ghana, Burkina Faso and Nigeria (Obeng-Ofori *et al.,* 2007).

2.5.1 Cultivars

Numerous cultivars vary in time-maturity, leaf colour, stem length, fruit shape and other characteristics (Obeng-Ofori *et al.*, 2007). Cultivars suitable for growing in Ghana are divided into two categories according to their time-to-maturity and use (Obeng-Ofori *et al.*, 2007). In Brazil, the most commonly grown cultivars are Colhe Bem and Santa Cruz 47 with both varieties producing round pods (Purquerio *et al.*, 2010) and currently, the most popular okra varieties grown in Florida are Annie Oakley, Cajun Delight, Clemson Spineless, North and South, and Spike (Simonne *et al.*, 2010). Below is a list of selected popular okra cultivars in some of West and Central African (WCA) countries.

Table 2.5 List of selected popular okra cultivars in some of WCA countries

Country	Name of cultivar
Senegal	Lolli, Indiana, POP- 11 (Emerald), Volta, Lima (F1), PoP- 12 (landrace)
Mali	Yelen, Clemson Spineless, Sabalibougou, Keleya
Cote d'Ivoire	Hire, Perkins Long Pod, Koto, Tomi (*A.caillei*)
Cameroon	Clemson Spineless, Volta, Emerald; Gombo Paysan, Gombo Cafeier
Togo	Konni (purified landrace), Local (*A.caillei*)
Ghana	Indiana, Saloni (F1),Asontem, Torkor
Nigeria	LD88, Clemsion, Spineless, Lady's Finger, V-35, White Velvet, Ex-Borno
Niger	Konni, Terra (purified landrace), Volta

Source: Kumar *et. al.*, 2010

2.5.2 Pests of Okra

There are many insect pests which may attack okra, but among those most likely to be troublesome are silverleaf whitefly, heliothis, rough bollworm, looper caterpillars and green vegetable bugs. Aphids and mites may also occur on okra crops. Table 2.5 indicates some of the major pests of okra and the damage they cause.

Table 2.6 Major Pests of Okra

Major pests	Comments
Aphids *(Aphis gossypii, Myzus persicae)*	Several species of aphids affect okra leaves and young fruits. Are very small, light to dark green, round insects that suck sap from okra leaves, causing leaves to turn yellow and become twisted; later plants may wilt and die
Cotton stainers (*Dysdercus spp.)* and other sucking bugs (*Nezara viridula)*	Cotton stainer adults and nymphs are very common on okra plants at fruiting stage and abundant during dry season. When strainers attack mature fruits, they damage the seeds. The bugs are conspicuously red, with black bands. They pierce through both young and mature fruits and suck the seeds inside. Attacked fruits shrivel and then fall. Other bugs that attack okra plants are stinking bugs and shield bugs. These bugs make feeding holes in okra fruits causing necrosis and these results in spotting, deformation and shedding of fruits.
Flea beetles (*Nisotra spp., Podagrica spp.)*	Very common pest that occur on almost all okra plants. Feed on okra leaves and make many small holes in the leaves
Root-knot nematodes (*Meloidogyne spp.)*	Several species of soil-living root-not nematodes are major pests of okra plants. These same species also attack egg plant, tomato, pepper, cabbage, carrot and other vegetables. Form swellings known as galls and other malformations on okra roots. Plant become stunted and may die

2.5.3.0 Diseases of okra

2.5.3.1 Wilt disease (*Fusarium pallidoroseum)* is soil-borne disease caused by two species of fungi that infect the roots, stems, leaves and fruiting stalks. Leaves initially show dark patches of mould on lower surface, then roll, wilt and drop off (MoFA, 2011).

2.5.3.2 Dumping off (*Pythium* spp) is a soil-borne fungus which kills seedlings through the root and stem. It causes rot of seeds after planting or kills young seedlings before they emerge. A brown watery soft-rot develops, the young stems are girdled and the seedlings fall over. Some of the preventive measures are (a) providing adequate spacing between rows (b) proper soil preparation to ensure good aeration, drainage and water holding capacity (c) soil sterilizer to reduce level of sun in soil and plants (d) avoiding over watering seedlings (e) ensuring adequate soil fertility to promote early vigorous growth (f) strict sanitation to avoid reinvesting treated soil (g) application of appropriate fungicides as soil drench as soon as first symptoms appear (Obeng-Ofori *et al.*, 2007).

2.5.3.3 Anthracnose disease *(Colletotrichum spp.)* affects leaves of okra, on which dark necrotic spots will begin to appear; later leaves become badly wrinkled and are then completely destroyed. Sometimes affects petioles of okra flowers and fruits causing many to drop off (MoFA, 2011).

2.5.3.4 Verticillium wilt is the most common disease affecting okra. The most conspicuous symptom is a yellowing of the older leaves, which often develop a burnt appearance, particularly around the margins, followed by wilting of the plant. The only control measures recommended are crop rotation and the destruction of diseased plants (Obeng-Ofori *et al.*, 2007).

2.5.3.5 Powdery mildew (*Oidium* spp) can become a major leaf problem in drier tropical regions. It may result in heavy leaf shed. Infected leaves become twisted, distorted and lose their chlorophyll rapidly. No chemicals are registered for powdery mildew on okra. Other preventive measures include elimination of weeds and avoiding over fertilization with nitrogen (Obeng-Ofori *et al.*, 2007).

2.6.0 Garden Eggs

Garden egg is scientifically known as *Solanum melongena* and belongs to the family *Solanaceae*. Egg plant also called garden egg or aubergine or Guinea squash, originated from India (Obeng-Ofori *et. al.*, (2007). It was introduced into Southern Europe in the middle ages by the Arabs and then distributed in Africa by Persians. Its cultivation in the Northern Sahara dates back more than 500 years. According to Obeng-Ofori *et al.*, (2007), the terms egg plant and aubergines are more common in Europe and the United States. The word garden egg is used only in West Africa for the crop. In South and South East Asia, the only term known is ‘brinjal’. The fruit is harvested immature before turning orange or red (Purseglove, 1968).

The crop thrives well on the warm, non-humid conditions found throughout the savannah belt of West and East Africa. The optimal temperature for the crop is 23-35 °C during days and 18-25 °C during nights (Obeng-Ofori *et al.*, 2007). It can grow on a wide range of well-drained soil rich in organic matter with an optimum pH ranging from 5.5 to 6.5 (Obeng-Ofori *et. al.*, 2007).

The most important production countries are Nigeria, Sudan, Cote d'Ivoire, Ghana, Madagascar, Cameroon and Djibouti (Obeng-Ofori *et al.,* 2007). According to FAO (2009), production of egg plant is highly concentrated with 85% output coming from five (5) countries. China is the top producer (56%) of world output) and India is second (26%), followed by Egypt, Turkey and Indonesia.

Garden egg is consumed almost on a daily basis by urban families and also represents the main source of income for producing households in the forest zones of West Africa (Danquah-Jones, 2000). In Ghana it is produced largely for the local market. Small amounts are currently exported, primarily to niche markets in the United Kingdom mostly for African consumers.

2.6.1 Pests of garden eggs

Garden egg is attacked by several pests which cause considerable damage to the crop with concomitant reduction in yield (table 2.6).

Table 2.7 Major Pests of Garden eggs

Major pests	Comments
Budworms (*Scrobipalpa blasigona)*	Small brown caterpillars of budworms bore into flower buds to feed inside flowers causing them to drop off and plant cannot produce many fruits
Epilachna beetles (*Epilachna chrysomelina)*	Is a major pest that feed on leaves of egg plants by scraping surface and reducing leaves to skeletons
Jassids (*Jacobiasca spp./Empoasca spp.)*	These are small, green and very mobile insects that live on lower side of upper leaves. Suck juice from leaves and inject poisonous substances that cause leaves to first turn yellow, then brown and dry, a condition known as 'hopper burn'
Mole crickets (*Brachytrupes spp)*	Live in soil, and attach and feed on roots of many vegetables. Attack seedlings or young transplants especially at nigt. Are large brown insects found mainly in sandy areas
Root-knot nematodes (*Meloidogyne spp)*	Are microscopically small, round worms that live in soil and in the roots of egg plants. Affected roots swell (gall) become malformed inhibiting plant growth.
Stem and fruit borers *(Leucinodes orbonalis)*	Whit larvae or caterpillars of the pest bore into top sections of fruits and stem of egg plants. Tunnel through stems causing plants to grow poorly and sometimes die prematurely. Fruits change colour and taste

White Flies (*Bemisia tabaci)*	Feed on leaves of eggplant sucking plant sap. Whiteflies are vectors of the mosaic virus reported to occasionally affect eggplant in West Africa. Apply neem products. Neem products have given control of the tobacco whitefly on eggplant
Thrips (*Thrips* spp and *Frankliniella* spp)	Attack eggplant mostly during the dry season. They cause browning of leaves, especially on the lower leaf surface. In severe cases, the entire leaf dries. Thrips feeding on fruits causesscarring, irregular discolouration and deformation, which reduce the market value of fruits.
Spider mites (*Tetranychus* spp.)	May become serious pests of eggplant during the dry season. Attacked leaves show a stippled appearance (white specks), and their surface covered with a fine web. Continuous infestation causes the leaves to dry-up. The plants are stunted and yields reduced.

2.6.2 Diseases of garden eggs

There are several diseases that affect garden eggs. Some of the most common include blossom end rot, wilt diseases, and various types of blight. Many of these diseases can be eliminated or prevented by practicing crop rotation, reducing weed growth, and providing adequate spacing and uniform watering.

2.6.2.1 Blossom end rot is caused from fungus due to overwatering and affects ripe fruit. Round, leathery, sunken spots appear on fruit ends with the affected fruit eventually dropping from the plant. (MoFA, 2011)

2.6.2.2 Bacterial wilt can cause plants to suddenly droop, from the bottom to the top, turning yellow. Affected plants eventually wither up and die. (MoFA, 2011)

2.6.2.3 Verticillium wilt is similar to bacterial wilt but is caused from soil-borne fungal infections. Plants may become stunted, turn yellow, and wilt. (MoFA, 2011)

2.6.2.4 Damping-off disease (*Pythium spp)* is a major disease that affects young seedlings in the nursery. Seedlings become constricted near ground surface and then collapse and many die. (MoFA, 2011)

2.7.0 Postharvest handling of vegetable crops

During postharvest handling, the produce is susceptible to physical damage and deterioration. Horticultural produce losses are as high as 50% due to inefficient postharvest procedures (Camargo and Perdas, 2002). However, produce losses vary widely depending on the type of produce, marketing time and the production region. Loss data also vary because different methods for assessing losses may be used and methods are rarely reported (Kader, 2002). Losses are estimated at 20-40% in developing countries and 10-15% in developed countries, depending on the crop. In the EU, an estimated 4 billion EUR is lost due to postharvest losses and reduced quality of vegetable fruits. Cortez *et al.*, (2002) estimated that about half of the losses are due to physical injuries and improper handling during storage and distribution. Presently, the percent loss of vegetable crops in Ghana was estimated at 20% with most losses occurring during harvesting, transportation, storage and grading and sorting (Egyir *et. al.*, 2008).

A report by Sargent *et al.*, (2007) stated that successful postharvest handling of vegetable crops require careful coordination and integration of the various steps from harvest operations to consumer level in order to maintain the initial product quality. They describe horticultural quality as those characteristics that the consumers associate with each commodity and which are dependent upon the particular end-use, such as sweetness, tenderness and crispness. Quality also refers to freedom from defects such as blemishes, mechanical injury, physiological disorders, water loss and decay. It is important to keep in mind that quality loss in fresh vegetable crops is cumulative: each incident of mishandling reduces final quality at consumer level.

Several factors reduce quality during postharvest handling, including:

- Harvesting at incorrect maturity stage
- Careless handling at harvest and during packaging and shipping
- Poor sanitation
- Delays to cooling or sub- optional cooling
- Shipping/storage above or below optimal temperature
- Lack of proper relative humidity
- For some sensitive commodities, exposure to ethylene gas.

Two of the most critical means to maintain vegetable quality during postharvest handling are minimising mechanical injury and managing temperature. Proper handling and temperature management will significantly reduce losses due to decay and accelerated senescence. Since vegetable crops are typically handled several times from harvest to retail level, personnel handling the crop must be properly trained and supervised (Sargent *et al.,* 2007).

2.8.0 Causes of postharvest losses

Postharvest begins at the moment of separation of the edible commodity from the plant that produced it by a deliberate human act (Ofosu-Anim, 2008). Loss means any change in the availability, edibility, wholesomeness or quality of the food that prevents it from being consumed by people (Harris and Lindbald, 1978). Food losses take place at production, postharvest and processing stages in the food supply chain. Food losses occuring at the end of the food chain (retail and final consumption) are rather called "food waste", which relates to retailers' and consumers' behaviour (Parfitt *et al*., 2010).

According to MoFA (2010), Ghana loses about 20%-50% of her fruits, vegetable crops, roots and tubers and about 20%-30% of cereals legumes annually, which has resulted in the country experiencing food insecurity.

Several factors influence postharvest losses in vegetable crops. The causes of food losses and waste in low-income countries are mainly connected to financial, managerial and technical limitations in harvesting techniques, storage and cooling facilities in difficult climatic conditions, infrastructure, packaging and marketing systems. Losses can also be mainly related to consumer behaviour as well as to a lack of coordination between different actors in the supply chain (FAO, 2011). Vegetable crops are characterized by high metabolic activities and known to possess short storage life (Sudheer and Indira, 2007). Due to these factors, significant loss occurs between harvesting to consumption.

Other factors such as insect and mite injury, diseases due to non-infectious pathogens and pathological rots are also responsible for postharvest loss of vegetable crops. Environmental factors such as temperature, relative humidity and oxygen balance especially in storage are also greatly responsible (Sudheer and Indira, 2007).
There are so many causes of losses in the postharvest food chain that it helps to classify them into two (2) groups and a number of sub-groups. Primary causes of loss are those causes that directly affect the food while secondary causes of loss are those that lead to conditions that encourage a primary cause of loss (Obeng-Ofori and Cornelius, 2008).

2.9.0 Primary causes of loss

2.9.1 Mechanical injury

Fresh fruit and vegetable crops are highly susceptible to mechanical injury owing to their tender texture and high moisture content. Poor handling, unsuitable packaging and improper packing during transportation are the cause of bruising, cutting, breaking, impact wounding, and other forms of injury in fresh fruits and vegetables (Choudhury *et. al.,* 2004). In most cases, mechanical injury received by vegetable crops due to pressure thrust during transportation, though sometimes invisible leads to rupturing of inner tissues and cells. Vegetable crops receive maximum mechanical injury during harvesting if proper means of picking and harvesting are not adopted (Sudheer and Indira, 2007).

2.9.2 Pathological action

Vegetable crops are susceptible to postharvest diseases that render the produce unfit to sell. Postharvest diseases can be spread through field boxes contaminated by soil or decaying produce or both, contaminated water used to wash produce before packing, decaying rejected produce left lying around the packinghouse, and contaminated healthy produce in packages. Microbial infection can occur both before and after harvest. The infection after harvest can be found at any time between the field and final consumer (Kanlayanarat, 2007). The invasion of fruit and vegetable crops by fungi, bacteria, insects and other organisms, is a major cause of postharvest losses.

Microorganisms readily attack fresh produce and spread rapidly, owing to the lack of natural defense mechanisms in the tissues of fresh produce, and the abundance of nutrients and moisture which support their growth (Choudhury *et. al.,* 2004). According to Sudheer and Indira (2007), an estimated 36% of vegetable crops decay is caused by soft rot bacteria. The most common pathogen causing rots in vegetable crops are fungi such as *Alternaria*, *Botrytis*, *Diplodia*, *Monilinia*, *Phomopsis*, *Rhizopus*, *Pencillium*, and *Fusarium*, and among bacteria *Erwinia* and *Pseudomonas* cause extensive damage.

2.9.3 Physiological factors

Natural respiratory losses which occur in all living organisms account for a significant level of weight loss and the process generates heat (Ofosu-Anim, 2008). According to Choudhury *et. al.*, (2004) physiological disorders occur as a result of mineral deficiency, low or high temperature injury, or undesirable environmental conditions, such as high humidity. Physiological deterioration can also occur spontaneously owing to enzymatic activity, leading to over ripeness and senescence, a simple aging phenomenon. A reduction in nutritional level and consumer acceptance may also arise with these changes. Production of ethylene results in premature ripening of certain crops (Ofosu-Anim, 2008).

2.9.4 Biological factors

Biological (internal) causes of deterioration include respiration rate, ethylene production and action, rates of compositional changes (associated with color, texture, flavour, and nutritive value), mechanical injuries, water stress, sprouting and rooting, physiological disorders, and pathological breakdown. The rate of biological deterioration depends on several environmental (external) factors, including temperature, relative humidity, air velocity, and atmospheric composition (concentrations of oxygen, carbon dioxide, and ethylene), and sanitation procedures (Bartz and Brecht, 2002).

2.10.0 Secondary causes of loss

Improper harvesting, storage, transportation and market facilities and legislation lead to condition favourable for secondary causes of loss. Inadequate harvesting facilities and rough handling during harvesting result in bruising and increased possibilities of contact of produce with soil which leads to contamination with organisms. A prolonged period taken for harvesting and grading in the field, leaves the produce with field heat for longer time which subsequently causes faster senescence (Sudheer and Indira, 2007). The use of improper machinery and equipment in mechanical harvesting causes serious losses. Harvesting of fruit and vegetable crops during rain or immediately after rains creates conditions favourable for decay organisms. Harvesting during hotter parts of day results in faster senescence, shriveling and wilting of fruit and vegetable crops compared to those harvested in early mornings or evenings.

Sudheer and Indira (2007) stated that inadequate storage facilities at producing or marketing centers leave the produce to natural causes of losses i.e., decay by organisms, respiration, transpiration and other biochemical reactions. Proper storage thus creates conditions unfavourable to these factors. Transportation and distribution of vegetable crops are important areas of postharvest loss. Physical and mechanical injuries occur during transportation and distribution. Longer shipment and distribution period eventually cause heavy losses. The earlier the harvested produce is consumed, the minimum is the loss, as the period of senescence and organism invasion, multiplication and damage is shortened. This can only be achieved by a well-setup marketing system.

The presence or absence of legal standards affects eventual retention or rejection of a vegetable crop for human consumption. Legal standards vary from country to country and are influenced by economic status and pressure of population on fruit or vegetable consumption (Sudheer and Indira, 2007). Strict legal standards give better prices to farmers and superior quality to consumers.

2.11.0 Miscellaneous losses:

According to Sudheer and Indira (2007), miscellaneous losses are numerous but some of the most important ones are as follows:

a. Over-purchase of cheap but highly perishable fruits and vegetables leading to wastage due to inadequate storage facilities.
b. Rates of pay among product haulers usually depend on the number of containers that they can carry from one point to another. Hence, they disregard proper handling in their hurried attempts to make more trips.
c. Deterioration during storage occurs because some old stocks are intentionally kept too long in anticipation of eventual price increases;
d. Maintenance of transport, storage and other handling facilities are generally poor in developing countries resulting in a continual source of losses.
e. There is no efficient communication link between producers and wholesalers. Losses will always occur in the absence of a dependable communication system.

2.12.0 Control of postharvest losses

Food security is a major concern in large parts of the developing world. Food production must clearly increase significantly to meet the future demands of an increasing and more affluent world population (FAO, 2011).Vegetable crops undergo a number of transfers during harvest, handling, packing and shipping operations. Each of these transfer points has the potential to reduce quality and therefore, subsequent postharvest life, by inflicting injuries such as bruises, cuts, punctures and abrasions or inoculating the product with microorganisms that cause decays (Sargent *et. al.*, 2007).The magnitude of postharvest loss in vegetable crops can be minimised by proper cultural operations, harvesting, transportation, storage and pre and post harvest treatment.

2.12.1 Cultural operations

Cultural practices are best management practices (BMPs) aimed at reducing the load of a specific compound, while maintaining or increasing economical yields. At the field level, adequate fertilizer rates should be used together with irrigation scheduling techniques (Lui *et al.*, 2012; 2013). Heavy application of nitrogenous fertilizers causes faster deterioration in fruit and vegetable crops but essential supply of potassic fertilizers improves keeping quality of fruit and vegetable crops. Deficiency of molybdenum and boron may induce heart rot in certain fruit and vegetable crops such as almond and cabbage.

In vegetable crops, mulching should be practiced as it conserves water and nutrients and keeps weeds under control and helps to obtain quality. Besides mulching obstructs reflection of soil heat and the produce has a longer keeping quality. Operations like staking in tomato, pea and other vain crops are useful in avoiding contact of vegetable crops with soil and thereby reduce decay subsequent to harvest (Sudheer and Indira, 2007).

2.12.2 Harvesting and field handling

Harvesting of fruits and vegetable crops should be done at cooler part of day and the produce should be shifted to packing shade as early as possible. Harvesting of vegetable crops during or immediately after rains should be avoided as it creates conditions most favourable for multiplication of microorganisms (Sudheer and Indira, 2007). High temperatures are very injurious to perishable products. In growing plants, transpiration is vital to maintaining optimal growth temperatures. Direct sources of heat, for example full sunlight, can rapidly heat tissues to above the thermal death point of their cells, leading to localized bleaching or necrosis (sunburn or sunscald) or general collapse (Kader, 2006).

2.12.3 Concept of packing house

Harvested crop has to be sent to a packing house for various unit operations like cleaning, grading post-grading, treatment and packing for transport and marketing. Such a system reduces postharvest losses considerably. According to Sudheer, (2007) almost all vegetable crops require special preparation before they are packed. All such operations such as washing, grading, waxing and pre-cooling of fruits should be performed in a parking house before packaging.

Packaging of fresh fruit and vegetable crops has great significance in reducing wastage. Packaging also provides protection from mechanical damage, undesirable physiological changes and pathological deterioration during storage, transportation and marketing. Through proper packaging, freshness, succulence and flavour of fruits and vegetable can be maintained for a longer period (Sudheer and Indira, 2007).

2.12.4 Improved transportation

Transportation and distribution of fruit and vegetable crops are the most important stages of postharvest loss. Kader (2002) stated that fresh produce is primarily transported by road, from farmer to consumer and marketing centers that fresh produce should be of the highest quality and should be kept in the best condition during transportation. In most developing countries, roads are not adequate for proper transport of horticultural crops. Also, transport vehicles and other modes, especially those suited for fresh horticultural perishables, are in short supply or absent. This is true whether for local marketing or export to other countries (Kader, 2005). In most cases vegetable crops are transported in non-refrigerated vehicles. Non-refrigerated vehicles are generally open trucks, container vans and other public vehicles. Fresh vegetable crops straight from the farm can be spoilt in hot climates due to lack of infrastructure for transportation, storage, cooling and markets (Rolle, 2006; Stuart, 2009). Subsequently, private sector investments can improve storage and cold chain facilities as well as transportation (Choudhury, 2006).

2.12.5 Reducing moisture loss

Prevention of weight loss from vegetable crops is a major advantage of consumer packaging where moisture retentive films are used particularly for leafy green vegetable and root crops. As a result, storage life of packaged produce is lengthened over non-wrapped produce particularly when marketing from refrigerator display cases. It is reported that moisture proof cellulose film, reduces weight loss of tomatoes by 25% the amount loss by non-wrapped tomatoes (Sudheer and Indira, 2007).

2.12.6 Temperature

Environmental conditions, mainly temperature, affect the quality of the fresh horticultural produce. Excessively low temperature causes chilling or freezing injury. High temperature increases produce respiration rate and water loss through transpiration, causing loss in internal flesh quality, shriveling and premature softening (Tanner and Smale, 2005). The ideal storage temperature for fresh peppers is 7.3°C, but they will last about one (1) week in a typical refrigerator (which should be at 4.5°C) (Harris, 1998). The lowest safe temperature for ripe and unripe tomato is 10 °C and 13 °C, 10 °C for garden eggs, okra is 7 °C while that of cabbage is between 0 °C and 2.5 °C (Kader, 2006).

2.12.7 Market facilities.

Kader (2005) suggested that, marketing cooperative organizations should provide a central point for assembling produce from small farmers and preparing commodities for transportation to markets and other distribution channels. Although the development of wholesale and retail markets should preferably be done by the private sector, local governments and marketing cooperatives can be instrumental in establishing and improving market facilities (Kader, 2005).

Vegetable crops should reach market as soon as possible and at a time they are needed most. An efficient marking system is essential to avoid losses of vegetable crops and also to get a good return from the sales (Sudheer and Indira, 2007).

2.12.8 Chemical treatment

Chemicals are applied to crops to manage microorganisms, to control pest infestations, to correct nutrients imbalances in the crop which shorten storage life or cause physiological disorders and prevent sprouting of crops. Control of microorganisms is of prime importance. Pre-harvest spraying of fungicides results in significance reduction of pathogens in harvested produce. The best method of application of fungicides and antibiotics is to mix them in wax emulsions. Benomyl or benlite is also good in preventing growth of most damaging fungi of tomatoes. Bacteria soft rot of packed spinach and lecture could be prevented by dipping streptomycin (1000 ppm). It also inhibits the activity of a number of microorganisms (Sudheer and Indira, 2007).

Electronic noses have been constructed that can "smell" and separate decayed fruits in packing houses and predict mycotoxin contamination. Postharvest treatments, such as application of reduced-risk fungicides, biological agents and natural products, heat treatment and edible coating formulations, alone or in combination, can be successfully applied to range of commodities including vegetable crops in order to prevent decay (Michailides and Manganaris**,** 2009).

2.13.0 Estimation of Postharvest Losses

According to Kader (2005), both quantitative and qualitative losses occur in horticultural crops between harvest and consumption. Qualitative losses (such as loss of caloric and nutritive value, loss of acceptability by consumers, and loss of edibility) are more difficult to assess than quantitative losses of fresh fruit and vegetable crops. While reduction of quantitative losses is a higher priority than qualitative losses in developing countries, the opposite is true in developed countries where consumer dissatisfaction with produce quality results in a greater percentage of the total postharvest losses.

Generally there are no accepted methods for evaluating post-harvest losses of fresh produce. Whatever evaluation method used may be the result referred only to a described situation (Egyir *et. al.*, 2008). Egyir *et. al.*, (2008) further stated that in the appraisal of an existing marketing operation, the accurate evaluation of losses occurring is a problem. These losses may be suspected to be too great but there may be no figures to support this view for the reason that:

- records do not exist;
- records, if available, do not cover a long enough period of time;
- the figures available are only estimates made by several observers;
- records may not truly represent a continuing situation; for example, losses may have been calculated only when unusually high or low;
- loss figures may be deliberately over- or understated for commercial or other reasons in order to gain benefits or to avoid embarrassment (Egyir *et. al.*, 2008).

Egyir *et. al.*, (2008) provide some simple steps to follow when estimating losses:

Step 1:

Evaluate quantity of commodity (j) held (tq) and lost (q_i) at each link in the chain specified by respondents. Commodity (j) *held* at the beginning of the link in a chain for the analysis is expressed on a per unit basis (eg 50 kg bag of pepper; 100 kg bag of cereal, average tubers of yam etc).

Step 2:

Find mean quantity (TQ_{ij}) held and lost (given ***n*** number of respondents) at each i*th* link in the chain per commodity (j).

Hence,
$TQ_{ij} = (\sum tq)/ n$

and

$Q_{ij} = (\sum q)/ n$

Step 3:

Calculate the ratio of mean quantity lost to initial mean quantity held at each link in the chain per commodity as loss ratio (Q_L)

Hence,

$Q_L = Q_{ij}/TQ_{ij}$

Step 4:

Find average of the sum of loss ratios for all links in the value chain for each commodity evaluated and calculate ***raw*** percentage loss per commodity. Hence,

$\%TQ_L = [\sum (Q_{ij}/TQ_{ij})]/ N * 100$

Where

$\%TQ_L$ = percentage post harvest loss per commodity along the chain

$Q_{i\ j}$ = mean quantity lost at each ith stage along the value chain of the jth commodity

TQ = mean total quantity at start of distribution of j*th* commodity[1]

N = total number of links along the chain

2.14.0 Pesticides

Pesticide Control and Management Act, 1996 (Act 528) of Ghana defines pesticides as any substance, mixture of substances or other agents used to control, destroy or prevent damage or protect something from a pest. The definition also includes chemical substances that are used to attract and repel pests as well as those used to regulate plant growth or remove coat or leaves. Under the US law, a pesticide may also refer to any substance or mixture of substances intended for use as a plant regulator, defoliant or desiccant.

In West Africa, there are no industrial units ensuring the synthesis of active materials through brandy laboratories (MoFA, 2011). Thus, the production of pesticides in the proper way is not effective in the whole of these countries. According to GCAP report finished products are rather imported notably through mother companies represented at the national level or active ingredients for formulation purposes. In Ghana, the following can be cited among others – Abuakwa Formulation unit, Wienco, Dizengoff, CHEMICO, Reiss & Co., Calli Ghana. Insecticide imports into Ghana has increased from 907 Mt in 2001 to over 5,078 Mt in 2009 (MoFA, 2010) with peak values of 6,921 Mt and 9,979 Mt in 2006 and 2007 respectively.The pesticides import statistics from 2007 to 2010 is provided in the table 2.7.

Table 2.8: Pesticide Import Statistics from 2007-2010

	2007		2008		2009		2010	
Formulated Pesticide Product	**Solid (Mt)**	**Liquid (Lt)**	**Solid (Mt)**	**Liquid (Lt)**	**Solid (Mt)**	**Liquid (Lt)**	**Solids (Mt)**	**Liquid (Lt)**
Insecticides	5.900	969,944	273.000	3,269,000	60.430	3,388,275	40.666	3,028,724
Herbicides	500.170	1,581,190	1,429.000	6,102,000	998.147	8,981,102	323.580	13,161,585
Fungicides	588.558	365,100	1,561.000	179,000	325.932	947,656	242.926	697,913
Nematicides	287.030	-	-	-	-	-	-	-
Others e.g. Plant growth regulators, wood preservatives etc	62.700	34,464	-	-	-	-	7.096	5,061
Totals	**1,444.36**	**2,950,698**	**3,263.000**	**9,550,000**	**1,384.51**	**13,317,033**	**614.27**	**16,893,283**
Grand Total	**4,395.06 Mt**	**12,813.00 Mt**	**14,701.54 Mt**	**17,507.55 Mt**				

Source: MoFA, 2011

Pesticides can broadly be divided into a number of groups or classes which relates to their functionality and structure. Examples of pesticide groups and specific pesticides within the groups are:

- organochlorine pesticides, e.g. DDT, dieldrin, chlordane, endosulfan;
- organophosphorus pesticides, e.g. parathion, dimethoate, chlorpyrifos;
- synthetic pyrethroid insecticides, e.g. deltamethrin, permethrin, fenvalerate;
- carbamate pesticides, e.g. aldicarb, propoxur, carbofuran;
- fungicides, e.g. chlorothalonil, vinclozolin; and
- herbicides, e.g. simazine, atrazine.

The organochlorine (OC) pesticides are among the major types of pesticides, notorious for their high toxicity, their persistence in the physical environment and their ability to enter the food chain (Ntow, 2001). Most of the compounds that fall into the organochlorine category have been banned for food applications since the late 1970s or early 1980s. The cyclodienes (dieldrin, aldrin, chlordane and heptachlor) have been used as termiticides until 1992, but have been totally banned for use since then (Stevens, 1991). Lindane is an example an organochlorine pesticide used by vegetable farmers in Ghana. Tables 2.8 and 2.9 shows a list of some provisionally cleared and banned pesticides in Ghana as at 30th November, 2012.

Table 2.9: List of Some Provisionally Cleared Pesticides (PCL)

Trade Name	Provisional Clearance Permit No. / Date of Issue	Concentration of Active Ingredient	Crops/Uses	Company
Plan D	PCL/1202/00379G February 2012	Deltamethrin (12.5g/l)	Insecticide for the control of insect pests in various crops	Agrimat Limited, Accra
Bypel 1 (PrGV.BT)	PCL/12103/00291G July 2012	*Perisrapae Granulosis Virus + Bacillus thuringiensis(5)*	Bio-insecticide for the control of Diamondback beetle and *Pieris rapae* in cabbage	Abnak Agro Services, Kumasi
Sumifax 200 EC	PCL/1264/00382G November 2012	Fenvalerate (200g/l)	Insecticide for the control of insect pests in vegetables and public health	Kofamob Agro Services, Kumasi
Termex 48EC	PCL/1224/00326G November 2012	Chlorpyrifos-ethyl (480g/l)	Insecticide for the control of insect pests in vegetables and pulses	Saro AgroSciences, Accra
Agrithane 80WP	PCL/1202/00378G Febuary 2012	Mancozeb (800g/kg)	Fungicide for the control of leaf spots, mildew, leaf blight and scab diseases in vegetables, fruits and ornamentals	Agrimat Limited, Accra
Famous 72 WP	PCL/12109/00299G November 2012	Metalaxyl (18%) +Mancozeb (64%)	Fungicide for the control of diseases in vegetables, fruits, ornamentals and field crops	Ghanima Agrochemicals, Kumasi
Rainpropzol 250 EC	PCL/1299/00310G November 2012	Propiconazole (250g/l)	Fungicide for the control of diseases in vegetables	Rainbow AgroSciences, Accra
Bo Adwuma 48 SL	PCL/1248/00300G November 2012	Glyphosate (480g/l)	Herbicide for the control of annual, perennial grasses and broadleaf weeds	Yawussma Ventures Kumasi
Afuo Wura 48 SL	PCL/12108/00307G November 2012	Glyphosate (480g/l)	Herbicide for the control of emerged annual and perennial broadleaf weeds,	Wofa Addo Agyenkwa Farms Co. Ltd,

			sedges and grasses	Techiman
Atrazila 500 SC	PCL/1243/00372G February 2012	Atrazine (500g/l)	Herbicide for the control of annual, perennial grasses and broadleaf weeds	Kumark Company Limited, Kumasi
Bellazine 500 SC	PCL/1205/00375G February 2012	Atrazine (500g/l)	Herbicide for the control of annual, perennial grasses and broadleaf weeds	Chemico Limited, Tema

Source: Environmental Protection Agency (EPA)

Table 2.10: List of Banned Pesticides in Ghana

2,4,5-T and its salts and esters	Dieldrin	Dinitro-*ortho*-cresol (DNOC)
Aldrin	Dinoseb and its salts and esters	Parathion
Binapacryl	Endrin	Methyl Bromide
Captafol	HCH (mixed isomers)	Phosphamidon
Chlordane	Heptachlor	Monocrotophos
Chlordimeform	Hexachlorobenzene	Methamidophos
Chlorobenzilate	Parathion	Mirex
DDT	Pentachlorophenol and its salts and esters	Toxaphene

Source: Environmental Protection Agency (EPA)

One exception is the organochlorine endosulfan which is permitted for use on a wide range of fruit and vegetable crops, and grains. Endosulfan has advantages over many of the earlier organochlorines in that it is not persistent in the environment. For most fruit and vegetable crops, 50% of residues are lost in 37 days and in animals, endosulfan is metabolised and excreted in the urine (Kidd and James, 1991) and does not accumulate in milk, fat or muscle (ibid) (Andrew and Simon, 1998).

Organophosphate insecticides

Organophosphates are some of the most widely used pesticides in the world. There are more than 40 different organophosphate pesticides on the market today, and each causes acute and sub-acute toxicity. Organophosphates are used in agriculture, homes, gardens and veterinary practices, replacing the same uses as the organochlorines, many of which have been banned for years. In general, they are not persistent in the environment as they breakdown quickly. They have been a suitable replacement for the more persistent organochlorine because of their relatively fast rate of degradation (Watson *et. al.*, 2003).

The organophosphorus pesticides are cholinesterase inhibitors and as such can pose a significant occupational health and safety hazard for farm workers and can be fatal to small animals, birds and fish (Andrew and Simon, 1998). Organophosphates are all derived from phosphoric acid and are generally the most toxic of all pesticides to vertebrate animals. They are chemically unstable and exert their toxic action by inhibiting the cholinesterase enzymes of the nervous system which results in the accumulation of acetylcholine. This interferes with neuromuscular junctions producing rapid twitching of the voluntary muscles and eventually paralysis. There are three main groups of organophosphates; phenyl, aliphatic and hetercyclic (Hodgson *et. al.*, 2004). Organophosphates commonly used in Ghana on vegetable crops include dimethoate, profenofos, chlorpyrifos and malathion.

Ntow et. al (2006) reported that although the production and use of many types of OCs and organophosphorus (OPs) have been severely limited in many countries including Ghana, they are, nevertheless, still being used unofficially in large quantities in many parts of Ghana, and in other developing countries because of their effectiveness as pesticides and their relatively low cost.

Synthetic pyrethroids

The synthetic pyrethroids are presently used extensively in most countries and have become the most significant class of agricultural insecticides since their introduction in the early 1980s. They have permitted applications in food crops (including fruits, vegetables and grains) as well as meat animals (Andrew and Simon, 1996). As a class, they possess a number of significant advantages over most organophosphorus and organochlorine insecticides. These advantages include low toxicity to mammals and birds, rapid breakdown in the environment and rapid elimination from animals (Kidd and James, 1991). Examples used in Ghana on vegetable crops are cypermethrin and deltamethrin.

Herbicides are generally less toxic to humans than insecticides. A number have been developed to inhibit metabolic pathways specific to plants (e.g. glyphosate inhibits the shikimic acid cycle in plants) and accordingly, have very low toxicity to animals (Andrew and Simon, 1998).

A report by Andrew and Simon (1998) explained that the N-methylcarbamate group of pesticides is derived from carbamic acid. As a class they are highly effective and have a broad spectrum of activity as insecticides, acaricides and nematicides. The carbamates are also cholinesterase inhibitors but, as a class, are less toxic than the organophosphorus insecticides. The carbamates generally degrade rapidly in the environment. Examples of these carbamates include carbofuran, fenobucarb and carbaryl (Robert, 2002).

The fungicides are not a chemically related class of compounds; therefore, generalisations on toxicity are not applicable. Many fungicides have broad ranges of permissions for use on fruit and vegetable crops and a number are seen regularly in samples analysed by the ACT Government Analytical Laboratory (ACTGAL). Some common examples of fungicides used on vegetable crops in Ghana are, Folpan, Merpan, Funguran, Shavet, and Kocoide 2000 (EPA, 2012).

List of some revised registered pesticides as well as a summary of register of pesticides as at 30th November 2012 are shown in tables 2.10 and table 2.11 below.

Table 2.11: List of Some Revised Register of Pesticides

Fully Registered Pesticides (FRE)

Trade Name	Registration No. / Date of Issue	Concentration of Active Ingredient	Crops/Uses	Company
Akape 20 SC	FRE/1202/00520G November 2012	Imidacloprid (200g/l)	Insecticide for the control of insects pest of vegetables	Agrimat Limited, Accra
Akate Master	FRE/1005/00309G November 2010	Bifenthrin (27g/l)	Insecticide for the control of capsids and insect pests in cocoa	Chemico Limited, Accra or Tema
Confidor 200 SL	FRE/1001/00296G November 2010	Imidacloprid (200g/l)	Insecticide for the control of capsid bugs and insect pests in cocoa	Wienco Ghana Limited, Accra
Champion 80 WP	FRE/1005/00305G November 2010	Copper Hydroxide (77%)	Fungicide for the control of fungal diseases in cocoa and coffee	Chemico Limited, Tema
Contizeb 80 WP	FRE/1278/00445G February 2012	Mancozeb (800g/kg)	Fungicide for the control of leaf spots, mildew, leaf blight and scab in vegetables and fruits	Five Continents, Accra
Folpan 50WP	FRE/11100/0393/G October 2011	Folpet (500g/l)	Broad spectrum fungicide for the control of diseases in vegetables, field crops and ornamentals	Makhteshim Agan West Africa, Accra
Kocide 2000	FRE/1206/00245G February 2012	Cupric hydroxide (53.8%)	Fungicide for the control of cocoa diseases	Calli Ghana Limited, Accra

Merpan	FRE/11100/00395/ G October 2011	Captan (500g/kg)	Broad spectrum fungicide for the control of diseases in fruits, coffee, vegetables and ornamentals	Makhteshim Agan West Africa, Accra
Adwumapa SL	FRE/1071/00323G November 2010	Glyphosate (480g/l)	Herbicide for the control of annual, perennial grasses and broadleaf weeds in cereals and vegetables	Chinese Woman Agro Company Ltd, Kumasi
Adwuma Wura 480 SL	FRE/1243/00419G January 2012	Glyphosate (480g/l)	Herbicide for the control of annual, perennial grasses and broadleaf weeds in cereals and vegetables	Kumark Company Limited, Kumasi
Chermosate 360 SL	FRE/1005/00313G November 2010	Glyphosate (360g/l)	Herbicide for the control of annual, perennial grasses and broadleaf weeds in cereals and vegetables	Chemico Limited, Tema
Focus Ultra 100 EC	FRE/1198/00369G August 2011	Cycloxydim (100g/l)	Herbicide for the control of annual and perennial grasses	Cama Agro Consult, Accra

Source: Environmental Protection Agency (EPA), 2012.

Table 2.12: Summary of Register of Pesticides as at 30th November 2012

Category	FRE	PCL	Banned	Total
Insecticides	119	10	26	**155**
Fungicides	33	4	-	**37**
Herbicides	72	31	-	**103**
Rodenticides	1	2	-	**3**
Plant Growth Regulators	5	-	-	**5**
Total	**230**	**47**	**26**	**303**

Source: Environmental Protection Agency (EPA)

2.14.1 Effect of Pesticides on Health

Vegetable production is a key component of Ghana's food security strategy (Parker *et al*., 2010). Common insecticides used against vegetable crop pests in Ghana include; Attak, Desbin, PAWA-karate, Dursban 4 E, Fura 3G, Bossmate 2.5 E and Pyrinex. Most vegetable farmers in Ghana (87%) use synthetic chemical pesticides to control pests on vegetable crops including a number of highly persistent organochlorine pesticides (Essumang *et al*., 2008). According to Farag *et al*., (2011) poor enforcement of regulations have allowed inappropriate application practices to develop, such as mixing of two or more pesticides. Lack of knowledge of the types, use and the effects (additive, synergistic, independent and antagonistic) of these pesticides among small and large scale farmers has resulted in their misuse and consequently their accumulation in various foods and feed items (Essumang *et al*., 2008; Farag *et al*., 2011).

Pesticide use raises a number of environmental concerns. Over 98% of sprayed insecticides and 95% of herbicides reach a destination other than their target species, including non-target species, air, water, and food (Miller, 2004). In recent times, the extent of the use of pesticides, and their mode of application including their abuse especially in agriculture have been of much concern to environmental scientists. Alongside their uses are also the residual effect of these pesticides and particularly their replicating effect on human health (Hurst *et. al*., 1991). Edwards (1986) established that pesticides could become a nuisance if they are misused, some of the negative effects of pesticide misuse include low crop yield, destruction of soil micro-fauna and flora, and undesirable residue accumulation in food crops.

Organophosphates (produced since the 1940s) and carbamates are insecticides used extensively in pest control. Organophosphates (OPs) and carbamates exert their effects on insects and mammals including human beings, by inhibiting the enzyme acetylcholinesterase at nerve endings (Clarke *et al.*, 1997). The normal function of acetylcholinesterase is the hydrolysis and resultant inactivation of acetylcholine. The character, degree and duration of acute illness produced by cholinesterase inhibiting OPs and carbamates are all directly related to the dose and route of exposure which in turn determine the degree and rate of acetylcholinesterase inhibition and subsequent accumulation of acetylcholine (Rosenberg, 1990). Symptoms produced are a manifestation of the parasympathetic hyperactivity due to the accumulated acetylcholine. These include neuromuscular paralysis and central nervous system dysfunction. Death may result from respiratory failure secondary to pulmonary oedema, bronchoconstriction and respiratory muscular paralysis. Cardiac arrhythmias and epileptic seizures may also occur (Rosenberg, 1990).

Jiries *et al.*, (2002) stated that the contamination of lagoons is a major source of concern since it is the habitat for fish and other aquatic organisms such as mussels, oysters, prawns and lobsters which are major sources of protein for most people in Ghana. Jiries *et al.*, (2002) further established that an uncontrolled chemical activity in water bodies implies a high rate of exposure to humans, who obtain much of their protein nutrition from these sources, and also to those who consume vegetable crops produced using such waters as means of irrigation. In addition, pesticides end up in the tissue of aquatic organisms and bio-accumulates with time.

According to WHO (1990), no segment of the population is completely protected against exposure to pesticides and the potentially serious health effects, though a disproportionate burden, is shouldered by the people of developing countries. The world-wide deaths and chronic diseases due to pesticide poisoning number about 1 million per year (Environews Forum, 1999). Northern Presbyterian Agricultural Services (NPAS), (2012) reported that the most common problems experienced by farmers during and after the application of pesticides include skin irritations, headaches, general body weakness, difficulty in breathing and dizziness. According to NPAS, (2012) report, fifteen (15) farmers died from suspected pesticide poisoning in the Upper East region in late 2010 and further explained that most of these deaths resulted from poor storage of pesticides, which seeped into food stocks.

2.14.2 Pesticide Residue Analysis

According to Codex, “pesticide residue” means any specified substances in food, agricultural commodities, or animal feed resulting from the use of a pesticide. The term includes any derivatives of a pesticide, such as conversion products, metabolites, reaction products, and impurities considered to be of toxicological significance. The term “pesticide residue” also includes residues from unknown or unavoidable sources (e.g. environmental), as well as known uses of the chemical) (Codex Alimentarius Commission, 2009)

Pesticide residues on crops are monitored with reference to maximum residue limits and are based on analysis of the quantity of a given residue remaining on food product samples. The Maximum Residue Limit (MRL) is not a health-based exposure limit and thus exposure to residue in excess of an MRL does not necessarily imply a risk to health (Boobis *et al*., 2008). This is because the use of a pesticide would not be allowed if the proposed MRL resulted in long-term and short-term exposure of pesticide residue and the human diet above safety limit (Armah, 2011).

In order to implement the joint FAO/WHO Food Standard Programmes, Codex Alimentarius Commission, comprising 120 member nations, was established in 1964. The Codex Committee on Pesticide Residues (CCPR) is a subsidiary body of the Codex Alimentarius commission that advises on all matters related to pesticide residues. Its primary objective is to develop Maximum Residue Limits (MRLs) in order to protect the health of the consumer while facilitating international trade. Maximum residue limit is the maximum concentration for a pesticide residue on crop or food commodity resulting from the use of pesticides in accordance with Good Agricultural Practice (GAP) (Barkat, 2005).

According to Farag *et al*., (2011) reliable pesticide residue analysis may be of immense significance as indicators of the potential risks of pesticide exposure on human health. Pesticide residue analysis is carried out for monitoring food and the environment. Various biological and chemical techniques (immunoassay, thin layer chromatography and capillary electrophoresis, etc.) can be used efficiently to determine pesticide residues but the most popular methods for this type of analysis are gas chromatography (GC) and liquid chromatography (LC). Capillary GC with different sensitive and selective detection systems, including mass spectrometry (MS) have been the predominant methods of analysis in multi-residue determinations in recent decades (Barkat, 2005).

Analysis of some organochlorine and organophosphorus residue levels in tomato by Essumang *et al.,* (2008) indicated that chloropyrifos, which is an active ingredient of pesticides registered in Ghana under the trade name dursban 4E or terminu 48o EC for use on vegetable crops, has the greatest residue level of 10.76 mg/kg. The lowest residue level observed was that of the pirimiphos-methyl with 0.03 mg/kg. Human risk assessment was performed on the results obtained from the analysis using Human Health Evaluation computerized software-RISC 4.02. The risk assessment showed cancer risk for adults and children due to the presence of endosulfan and chlopyrifos. Endosulfan is not registered in Ghana as a pesticide for use on vegetable crops; therefore, the detection of endosulfan in several samples indicates misuse of agrochemicals among Ghanaian farmers (Essumang *et al.*, 2008)

2.15.0 Maximum Residue Limits (MRLs)

MRLs are the maximum allowed concentrations of pesticide residues in or on food products. They ensure that pesticide residues in food do not constitute an unacceptable risk for consumers. All foodstuffs intended for consumption in the EU are subject to MRLs, i.e. fresh fruit and vegetable crops, preserved fruit and vegetable crops, wine, cereals and cereal products, products of animal origin (such as honey). Products containing more pesticides than allowed are withdrawn from the EU market (EU, 2012).

Hence, MRLs reflect the use of minimum quantities of pesticides to achieve effective plant protection, applied in such a manner that the amount of residue is the smallest practicable and is toxicologically acceptable. Before a MRL is established, a risk assessment has to prove that the limit is safe for the consumer health. MRLs are established for three key reasons: to ensure that the residues on food do not pose an unacceptable risk for the health of consumers, to ensure that pesticides are used in accordance with the authorized uses, respecting the label instructions and to avoid trade barriers. In most cases the MRLs are well below the toxicologically acceptable residue levels. Thus, if a pesticide residue is found on a given crop at or below the MRL, then the crop can be considered safe for the consumer health. On the other hand, if a residue exceeds the MRL, it is not necessarily true that the consumer is at risk (EFSA Scientific Report, 2009).

The MRLs for cabbage, tomato, okra and sweet pepper are shown in tables 2.12 - 2.14

Table 2.13 EU Maximum Residue Limits (MRLs) for cabbage

Peak name	MRLs	Year of adoption
Allethrin	0.5 mg kg^{-1}	2008
Bifenthrin	0.5 mg kg^{-1}	1995
Cyfluthrin3	0.1 mg kg^{-1}	2008
Fenvalerate	3.0 mg kg^{-1}	...
Permethrin	5.0 mg kg^{-1}	...
Lambda-cyhalothrin	0.3 mg kg^{-1}	2009
Deltamethrin	2 mg kg^{-1}	...
Cypermethrin	0.7 mg kg^{-1}	2009
Methamidophos	1.0 μg g^{-1}	...
Ethoprophos	0.02 μg g^{-1}	2005
Phorate	0.05 μg g^{-1}	2006
Diazinon	0.5 μg g^{-1}	2005
Chlorpyrifos	1.0 μg g^{-1}	2003
Malathion	0.5 μg g^{-1}	2006
Parathion-et	0.05 μg g^{-1}	2004
Dimethoate	0.05 μg g^{-1}	2003
Fenitrothion	0.5 μg g^{-1}	...

Source: Amarh, (2011)

Table 2.14 Codex Alimentary Maximum Residue Level for tomato

Pesticide	**MRL**	**Year of Adoption**
Ethoprophos	0.01 mg/Kg	2005
Abamectin	0.02 mg/Kg	2001
Quintozene	0.02 mg/Kg	2003
Novaluron	0.02 mg/Kg	2006
Pyrethrins	0.05 mg/Kg	2003
Spinetoram	0.06 mg/Kg	2009
Hexythiazox	0.1 mg/Kg	1997
Methidathion	0.1 mg/Kg	
Triadimefon	0.2 mg/Kg	1997
Cypermethrins (including alpha- and zeta-cypermeth)	0.2 mg/Kg	2009
Tebuconazole	0.2 mg/Kg	1997
Cyfluthrin/beta-cyfluthrin	0.2 mg/Kg	2008
Myclobutanil	0.3 mg/Kg	1999
Dinocap	0.3 mg/Kg	2003
Mandipropamid	0.3 mg/Kg	2009
Deltamethrin	0.3 mg/Kg	2004
Pyraclostrobin	0.3 mg/Kg	2006
Spinozad	0.3 mg/Kg	2003
Bifenazate	0.5 mg/Kg	2007
Triadimenol	0.5 mg/Kg	1997
Imidacloprid	0.5 mg/Kg	2004
Carbendazim	0.5 mg/Kg	2001
Clofentezine	0.5 mg/Kg	2008

Source: JMPR, (2009)

Table 2.15 Codex Maximum Residue Limits for sweet peppers

Pesticide	MRL	Year of Adoption
Abamectin	0.02 mg/Kg	2001
Diazinon	0.05 mg/Kg	1995
Ethoprophos	0.05 mg/Kg	2005
Benalaxyl	0.05 mg/Kg	
Quintozene	0.05 mg/Kg	2003
Cypermethrins (including alpha- and zeta-cypermeth)	0.1 mg/Kg	2009
Triadimefon	0.1 mg/Kg	1997
Triadimenol	0.1 mg/Kg	1997
Trifloxystrobin	0.3 mg/Kg	2006
Tebuconazole	0.5 mg/Kg	1999
Cyprodinil	0.5 mg/Kg	2005
Fenarimol	0.5 mg/Kg	1999
Dimethoate	0.5 mg/Kg	2009
Fenvalerate	0.5 mg/Kg	
Dithiocarbamates	1 mg/Kg	1999
Thiacloprid	1 mg/Kg	2007
Azinphos-Methyl	1 mg/Kg	1995
Fenpropathrin	1 mg/Kg	1995
Fludioxonil	1 mg/Kg	2006
Methiocarb	2 mg/Kg	2006
Tolylfluanid	2 mg/Kg	2004
Chlorpyrifos	2 mg/Kg	2003
Bifenazate	2 mg/Kg	2007

Source: JMPR, (2009)

CHAPTER THREE

METHODOLOGY

3.1 Study Location

The study was conducted in 10 selected vegetable growing areas in the Greater Accra region of Ghana. The selected towns include Dzorwulu, Obaakruwa, Ashaiman, Atomic, Kojo Ashong, Okushiabade, Onyaasanaa, Kordiabe, Abepaanya and Weija (Fig 3.1).

The Greater Accra Region is the smallest of Ghana's 10 administrative regions in terms of area, occupying a total land surface of 3,245 square kilometres or 1.4 percent of the total land area of Ghana. In terms of population, however, it is the second most populated region, after the Ashanti Region, with a population of 4,010,054 in 2010, accounting for 16.3 percent of Ghana’s total population (Ghana Statistical Service, 2012). It contains 10 districts made up of 2 metropolitan, 6 municipal and 2 districts as follows: Accra Metropolitan District, Adenta Municipal District, Tema Metropolitan District (Ghana Districts .com).

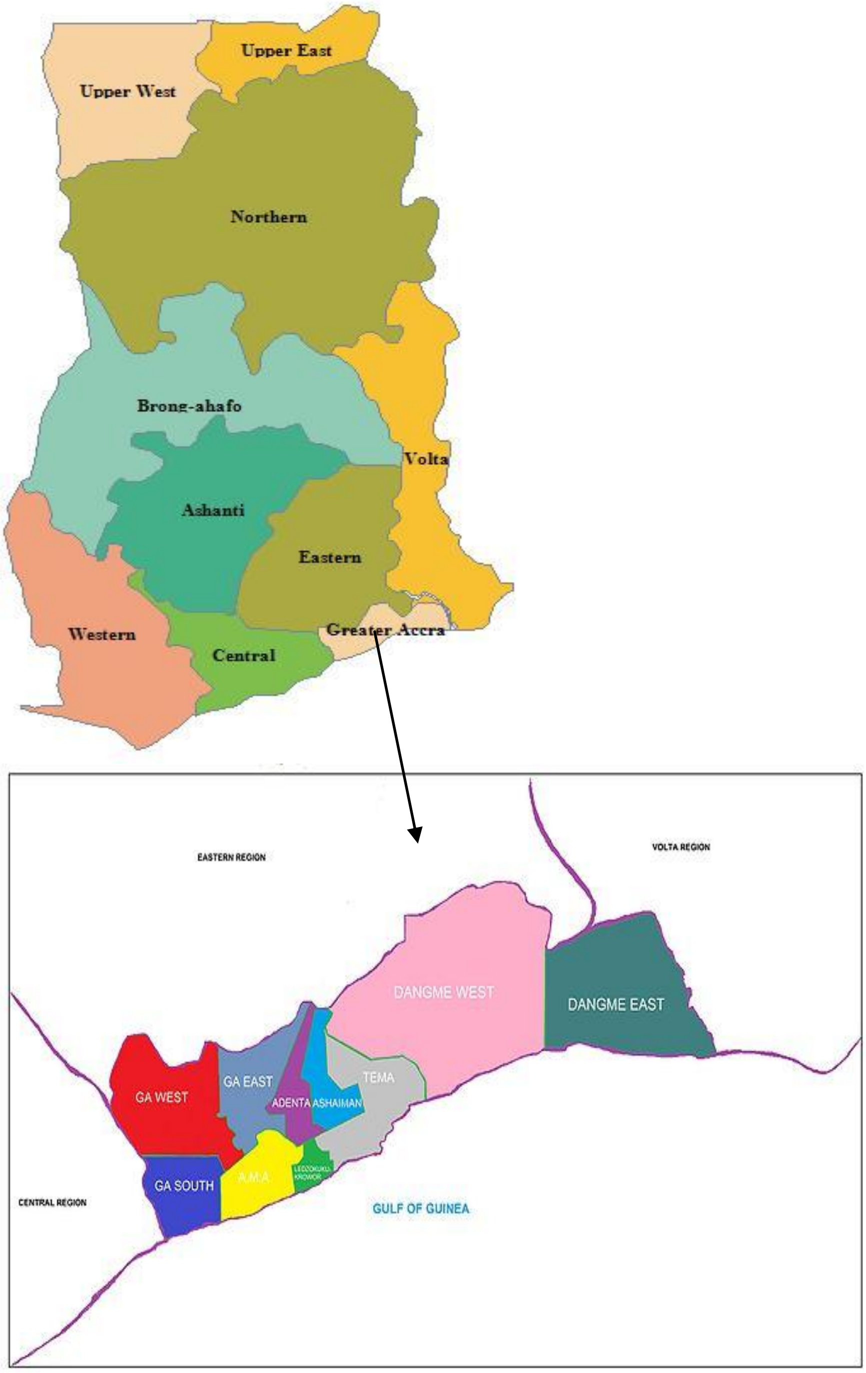

Figure 3.1 Map of Ghana indicating the various districts and the study sites in the Greater Accra

3.2 Questionnaire Administration

Questionnaires that had both open and closed-ended questions were developed and administered to farmers and traders. The questionnaires were administered to one hundred (100) vegetable farmers randomly selected within the 10 selected vegetable growing areas in the Greater Accra region with the help of the Agriculture Extension Service, MoFA while seventy-five (75) vegetable traders were randomly selected from three markets namely Madina, Makola and Agbogbloshie and interviewed on subsequent visits to the market. In all, 20 farmers cultivating pepper, tomato, cabbage, egg plant and okra respectively were interviewed while 15 traders trading in the selected vegetable crops were also interviewed. For the 100 farmers interviewed, about 90% were males with only 10% being females. On the other hand the 75 traders interviewed were all females.

A personal interview was conducted with these stakeholders on the selected vegetable production, harvest and harvesting operations, storage practices, losses incurred at the farm level, and marketing of the produce. Information was also obtained on pesticide usage by farmers. Individuals were interviewed in an attempt to get the respondents to explore his/her knowledge and views in the area being studied.

3.3 Data Collection

The questionnaires were pre-tested with 10 farmers at Ashaiman Irrigation Project area in the Adenta Municipality from October to November 2011. After the pre-testing exercise, the questionnaires were refined with other information from previous surveys.

The main focus was determining the postharvest losses in cabbage, tomato, pepper, okra and eggplant.

Important information sought in the questionnaires included:

- Personal profiles of respondents,
- The different husbandry practices for the production of the target vegetable crops,
- How and where they store their produce,
- Extent and value of losses
- Factors responsible for losses
- Measures employed to control postharvest losses,
- Types of pesticides used, frequency of application and spraying intervals,
- Dosage of chemical used,
- Protective measures while spraying,
- Disposal of pesticide containers, and
- Health harzards.

3.3 Estimation of post harvest losses of some common vegetable crops grown in the Greater Accra Region of Ghana.

The quantity harvested, estimated loss and the value of loss for cabbage, pepper, tomato, egg plant and okra were estimated from survey data collected from the farmers. An average of the estimated loss stated by farmers was calculated. The estimated loss for cabbage was calculated using number of heads, tomato by 52 kg crate, while eggplant, okra and pepper were calculated using 50 kg as the standard weight. Value of loss in Ghana cedis was calculated by the product of the average estimated quantity lost and the unit price.

Value of loss (GH¢) = average estimated loss x unit price of commodity

3.4 Analysis of pesticide residues in okra

The types of equipment used for the residue analysis are listed in table 3.1. A kilogram of okra sample from four farms in Weija, Ashaiman, Dawenya and Atomic Energy were taken and sent to the Pesticide Residue Analysis Laboratory of the Ghana Standard Authority. The analytical methods for pesticide residues in foodstuffs, General Inspectorate for Health Inspection, Ministry of Public Health, Water and Sport, The Netherlands, (1996) was used to detect and quantify the amount of pesticides used during the okra cultivation.

Table 3.1 Types of equipments used

Equipment	**Type**
Gas Chromatography	Varian CP-3800 Gas Chromatography with a CombiPAL Autosampler and Electron Capture Detector
Analytical column	30m + 10m EZ Guard x 0.25mm internal diameter fused silica capillary coated with VF-5ms (0.25µm film) from Varian Inc. or equivalent
Centrifuge	Hermle Z 300, Jouan CR3i multifunation
Macerator	IKA Ultra Turrax homogenizer
General laboratory glassware	Rounded bottomed flasks, volumetric flasks, centrifuge tubes
Water bath	Bibby, RE 200B and Buchi, B-491
Extraction jar	250ml capacity, Sample bottle
Preparation equipment	Waring Laboratory Blender
Rotary film evaporator (RFE)	Bibby RE 200 and Buchi Ratovapor R-210
Recirculation chiller	Buchi, B-740
Ultrasonic bath	Decon FS400b
Vortex mixer	Thermolyne (Maxi Mix-Plus)

The representative sample was homogenized with ethyl acetate, anhydrous sodium sulphate (Na_2SO_4) and sodium hydrogen carbonate ($NaHCO_3$) and the layers were separated by centrifugation. An aliquot of ethyl acetate phase was evaporated down, and cleaned up on an ENVI-Carb/LC-NH_2 SPE cartridge (for OPs) and Florisil SPE cartridge (OCs and SPs). The pesticides were eluted from the cleanup column with ethyl acetate. The eluate was concentrated and transferred into GC vial. The extract was then analysed for multiresidues by GC/PFPD (for OPs) and GC/ECD (for OCs and SPs).

About 20 ± 0.1g of a sub sample from the prepared matrix was weighed into a sample bottle. 40 ± 0.2ml of ethyl acetate was added and macerated for 30 seconds. Anhydrous sodium sulphate (20 ± 0.1g) and sodium hydrogen carbonate (5 ± 0.1g) were also added and macerated for 90 seconds. It was then centrifuged at 3000 rpm for 5 minutes.

Organophosphorus residues (OPs)

About 10 ml (5.0 g) of the aliquot was pipetted into a 50 ml round-bottomed flask and evaporated to about 2 ml below 40 °C on a rotary evaporator. The ENVI-Carb/LC-NH_2, (500 mg/500 mg, 6 ml) cartridge was conditioned with (10 ± 0.2 ml) of ethyl acetate. About 2 ml of the extract was loaded onto the cartridge and a 100 ml round bottomed flask was used to collect the eluate. The cartridge was eluted with 10 ± 0.2 ml of ethyl acetate and the filtrate concentrated to below 40 °C to approximately 1 ± 0.2 ml on the rotary evaporator just to dryness. About 1ml of ethyl acetate was used to re- dissolve and transferred into a gas chromatography (GC) vial for quantitation by GC-PFPD.

Organochlorine residues (OCs) and Synthetic pyretroids (SPs) residues

An aliquot of 4 ml (2.0 g) was pipetted into a round-bottomed flask (50 ml) and evaporated to about 2 ml below 40 °C on a rotary evaporator. 'Florisil' (1000 mg, 6 ml) cartridge was conditioned with 10 ± 0.2 ml of ethyl acetate. The extract was loaded from 9.1 (2 ml) onto the cartridge and the eluate was collected into a 100 ml round bottom flask. About 0.2 ml ethyl acetate was eluted in the cartridge and the concentrate filtrated below 40 °C to approximately 1 ± 0.2 ml on the rotary evaporator just to dryness. It was re-dissolved in ethyl acetate (1ml, standard opening vial) prior to quantitation using the Varian CP-3800 Gas Chromatography with a CombiPAL Autosampler and Electron Capture Detector (GC-ECD).

Chromatographic conditions for organochlorine and synthetic pyrethroids pesticides

The varian CP-3800-ECD with a combiPAL autosampler was used with an analytical column of 30m + 10m EZ Guard x 0.25mm internal diameter fused silica capillary coated with VF-5ms (0.25μm film) from Varian Inc. or equivalent. The syringe was examined carefully before it was filled. A small amount of the liquid was slowly drawn by raising the plunger and then pressed to expel the liquid back into the liquid. This served to "rinse" the syringe with the sample, ensuring that what was measured in the GC run was the composition of the mixture. The rinsing process was repeated twice in order to remove any contaminants. Then the plunger was slowly drawn up again while the needle was in the liquid and the syringe was carefully filled with the liquid. The sample was injected into the injector port. Two things were done sequentially and quickly. The needle of the syringe was pushed through the injector pot and immediately the plunger was pressed to inject the sample. The injector in the gas chromatograph was set at split mode at a temperature of 270 °C. Then immediately the start button on the recorder was pressed.

The oven was set at 70 °C/ 2min 25°C/min 180°C/1min 5°C/min 300°C. The detector-ECD was also set to a temperature of 300°C. A constant flow of nitrogen gas was passed through at 1ml/min. The recorder was observed for some time. Within several minutes, it recorded several peaks and the GC run was ended.

Chromatographic conditions for organophosphorus pesticides.

The same procedure was repeated for organophosphorus pesticide but the gas chromatograph used was the varian CP-3800 GC-PFPD with a combiPAL autosampler with an analytical column of 30m x 0.25mm internal diameter fused silica capillary coated with VF-1701ms (0.25µm film) from Varian Inc. or equivalent. The temperature of the oven was at 70 °C/min and held at 25 °C for 1min then at 200 °C/1min and held at 20 °C/min and 250 °C. The detector-PFPD was also set to a temperature of 280 °C. Nitrogen gas of constant flow was passed over at 1ml/min. Air 1; H_2 and Air 2 were applied at a flow rate of 17, 14 and 10, respectively. The recorder was observed for some time. Within several minutes, it recorded several peaks and the GC run was ended.

CHAPTER FOUR

RESULTS

4.0 Education status of Vegetable crop farmers and traders

The educational status of the vegetable farmers and retail traders in table 4.1 indicates that about 15% of farmers and 18% of the traders interviewed have not formal education. Overall, only 5% had education up to tertiary level, about 30% farmers and 17% traders had attended Senior high school while half of the farmers (50%) and traders (35%) had basic education that is, primary and junior high school. Also about 4% of the traders had other forms of education from catering and commercial schools.

Table 4.1: Educational status of farmers and traders

Educational level	Percentage of Farmers	Percentage of Traders
Primary	17%	9%
JHS	33%	26%
SHS	30%	17%
Tertiary	4%	1%
Islamic Education	1%	-
Commercial/catering school	-	4%
No formal education	15%	18%
Total	**100%**	**100%**

4.1 Area under cultivation

Although the study area comprised of farms in peri urban and urban in nature and as such difficult in accessing farm land, 57% of the farmers had between 1-2 acres of land devoted to farming (Fig. 4.1). Other range of land sizes under cultivation were 3.4 acres (9%), 5 acres and above (7%) and with 27% of farmers cultivating less than an acre of land. The average land under cultivation by participating farmers was 1.50, 2.25, 2.15, 2.50 and 2.20 acres for cabbage, pepper, eggplant, tomato and okra, respectively.

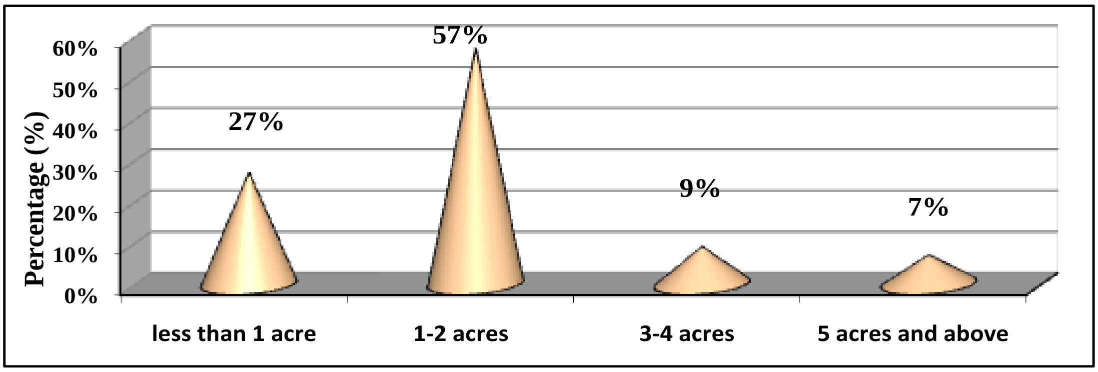

Figure 4.1: Range of land sizes under vegetable crop cultivation

The vegetable crops cultivated included both the local and exotic types. About 56% of farmers grew the local varieties and 39% cultivated the exotic types (Fig. 4.2). However, 5% grew both the exotic and the local vegetable crops. Generally, majority of the cabbage farmers preferred the oxylus, pepper farmers mostly grew Legon 18, bird eye and chilli types. Eggplant varieties preferred were the pink ravaya and white while tomato varieties grown included pectomect, raw stone, navrongo, and a local variety known as fitonyapio. Most okra farmers referred to their variety as the early type (i.e. Asontem and kontembrantem).

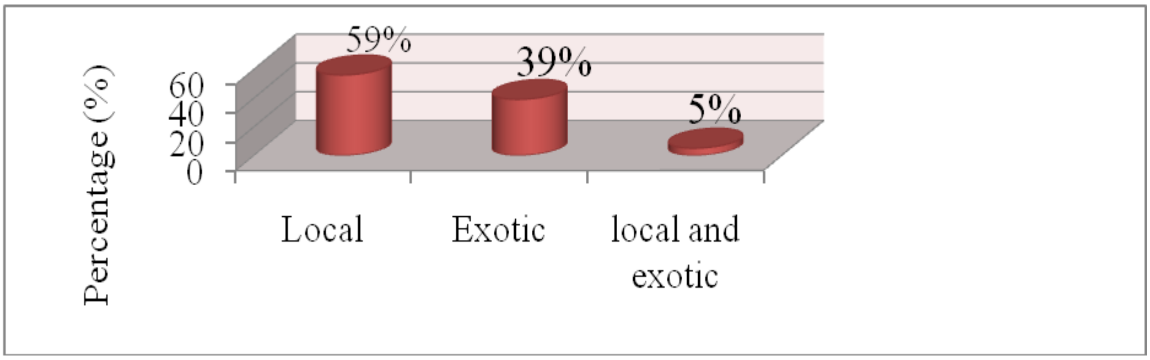

Figure 4.2: Type of vegetable crops grown by farmers

4.2 Source of planting materials

Among the vegetable crop farmers interviewed, about 44% of them obtained their seeds from registered seed retailers e.g. Agrimart. Information obtained also revealed that 24% of farmers produced their own seeds from previous harvest while 18% obtained seeds from fellow friends with only 6% from MoFA (Table 4.2).

Table 4.2: Sources of planting material for farmers

Source	Percentage
Friends	18%
MoFA	6%
Own Seed	24%
Agric Shop	44%
Exporters	2%
Agric Shop & Own Seed	2%
Own Seeds & Exporters	2%
Friends & Agroshop	1%
Family	1%
Total	**100%**

4.3 Harvesting of vegetable crops

From the survey, all the farmers employed manual methods for harvesting. Among the various manual methods employed in harvesting, the use of hand twisting (67%), knife cutting (22%) and cutlass (7%) (Table 4.3) were popular. Manual harvesting such as hand twisting and knife cutting increases postharvest losses through bruising, and transfer of disease infection.

Table 4.3 Manual methods for harvesting vegetable crops

Harvesting method	Percentage (%)
by knife cutting	22
by hand twisting	67
Cutlass	7
by blade cutting	2
Knife and hand twisting	2
Total	**100**

Harvesting of vegetable crops by the farmers was usually done in the mornings and evenings with about 28% harvesting at any time of the day. Majority of the farmers (86%) harvested and sold all their produce on the farm, 7% representing a part of pepper farmers sold the fresh green pepper and temporarily processed (boiling and drying) the ripe ones and stored them for the market. The other 7% of the farmers sent produce to the market after harvesting (Fig. 4.3).

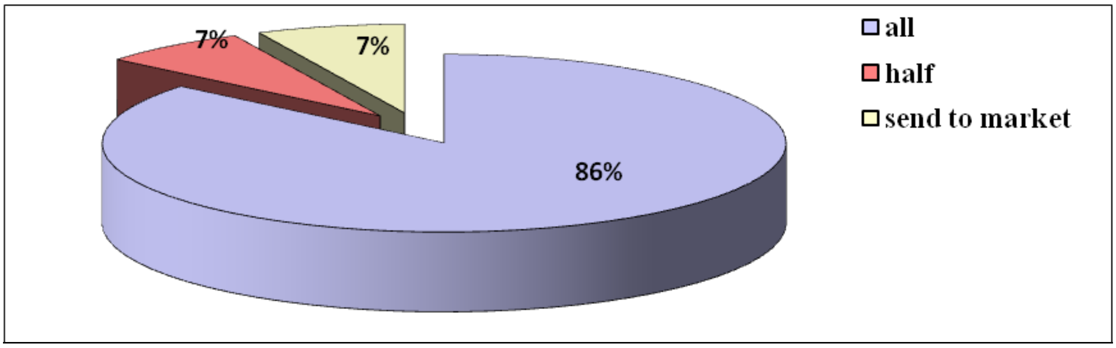

Figure 4.3 Sale of harvested vegetable crops

4.4 Farmers ability to identify pest

Among the common insect pests identified by respondents included worms, the diamondback moth, caterpillars, aphids and white flies. About 99% of farmers had experienced pest problems on their farms which caused various forms of damage to the vegetable crops. Some of the damage caused by the pests included feeding and creating holes in the leaves and fruits, feeding on the stem, sucking sap from fruit, leaves and stem causing them to shrink and wilt. Some of the pests destroy flowers which prevent fruiting of crop, cause discolouration of fruits and leaves, stunted growth and death of the plant. Most farmers also identified disease problems and were able to determine whether it was fungi, bacteria, nematodes and viruses. They mentioned diseases such as leaf curl, early and late blight and root knot. Some of the farmers indicated that weather conditions also caused disease to their vegetable crops. On the other hand a few of them could not identify which diseases attacked their produce.

4.5 Estimating postharvest losses at farmer and trader levels

Postharvest loss is a major problem experienced by farmers. About 83% acknowledged the fact that postharvest was a problem. Table 4.4 shows the quantity of each vegetable harvested, quantity lost and the value of loss incurred by farmers. The percentage loss at the harvesting operation was about 13% for cabbage, 12% for pepper, 1% for eggplant, 20% for tomato and 13% for okra. The value of loss by farmers was computed using the product of estimated and the cost of produce which resulted in Gh¢ 600, Gh¢300, Gh¢30, Gh¢360 and Gh¢210 for cabbage, pepper, egg plant, tomato and okra, respectively.

Table 4.4: Estimation of postharvest losses of selected vegetable crops

Vegetable Type/Unit	Average area cultivated in acres N=20	Average Quantity produced N=20	Average Estimated loss N=20	Cost per unit (GH¢)	Value of loss (GH¢)	% Estimated loss to quantity produced
Cabbage/ Heads	1.50	3100	400	1.5	600	12.90
Pepper/ 50 kg bag	2.25	34	4	75	300	11.76
Egg plant/ 50 kg bag	2.15	84	0.50	60	30	0.60
Tomatoes/Crates 52 kg	2.50	20	4	90	360	20
Okra/ 50 kg bag	2.20	23	3	70	210	13.04

The magnitude of losses according to the farmers interviewed depended on the nature of the commodity, the condition of the produce at the time of collection, distance travelled and the nature of the road network.

Table 4.5 shows the percentage of postharvest losses incurred by vegetable retail traders. About 14% for cabbage, 6% of pepper, 9% of tomato and 9% of okra were lost by the traders. These are valued at GH¢36, GH¢13.2, GH¢18 and GH¢14.5 for cabbage, pepper, tomato and okra, respectively. Loss of eggplant was insignificant due to its ability to maintain its freshness till it is sold to consumers.

Table 4.5: Loss incurred by vegetable traders

Vegetable Type/Unit	Average Quantity purchased N=15	Average Estimated loss N=15	Cost per unit (GH¢)	Value of loss (GH¢)	% Estimated loss to quantity produced
Cabbage/ Heads	125	18	2	36	14.4
Pepper/50kg bag	2	0.12	110	13.2	6
Egg plant/50kg bag	2	-	80	-	-
Tomatoes/Crates (52kg)	2	0.18	100	18	9
Okra/50kg bag	2	0.17	85	14.5	8.5

Causes of the losses during trading were attributed to the following;

- Cabbage: Rotting of fruits.
- Pepper: Rotting of fruits, wilting and shrinking.
- Tomato: Rotting and crushing of fruit.
- Okra: Rotting of fruit, wilting and shrinking.

4.6 Pesticide use

4.6.1 Pesticide use pattern of vegetable crop farmers

Due to the pest and disease attack, 95% of farmers applied pesticides to control insects and diseases that attacked their vegetable crops (Fig 4.4). The major reason of farmers preferring pesticides to other plant protection measures was the rapid knock down effect of pesticides against the pest. The chemicals used included fungicides, insecticides and herbicides. Only a few farmers (5%) practice the integrated pest management method.

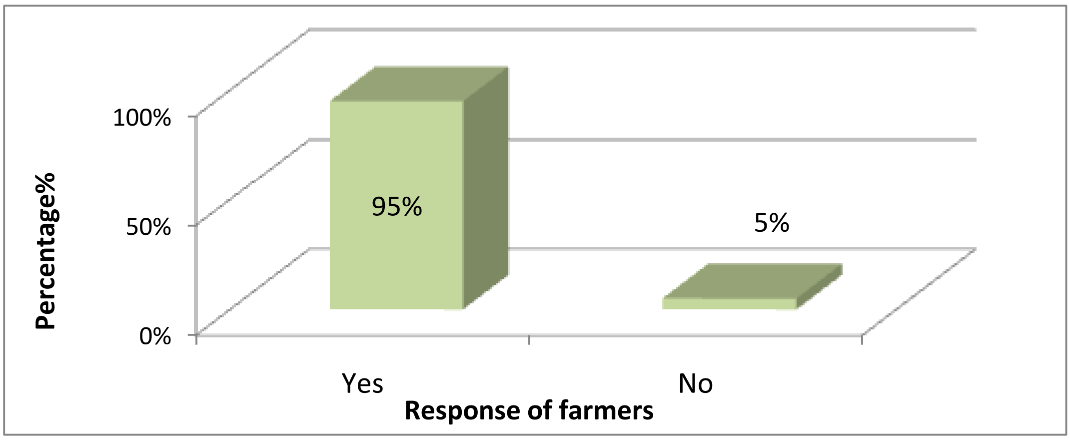

Figure 4.4 Response of farmers to pesticide use

Table 4.6 shows that farmers using fungicides and insecticides recorded the highest percentage of (47%) of the total farmers interviewed. Some of the farmers used insecticides, fungicides and herbicides independently while others combined two or more chemicals to control insect pests, diseases and weeds. The common pesticides used by the farmers are indicated in Table 4.7.

Table 4.6 Types of pesticides used by vegetable crop farmers

Type of pesticide	Frequency	Percentage (%)
Insecticides	29	31
Fungicides	3	3
Fungicide and Insecticide	45	47
Insecticides & herbicides	5	5
Insecticide, Fungicide & herbicide	10	11
IPM	3	3
Total	95	100

Table 4.7 Examples of some pesticides applied by vegetable crop farmers

Insecticides	Fungicides	Herbicides
Imidacloprid (Auntie Ataa)	Agrithene	Glyphocite
Acetamiprid (Golan)	Furadan	Round up
Emamectin benzoate (Attack)	Bendazim	Ejumawura
Cypermethrin (Cydim Super/ cymethoate Super)	Shavet	Paraquat
Deltapaz (Deltamethrin)	Topsin	
Diazinon (Diazol)	Sulphur 80	
Chlorpyrifos (Dursban)	Mancozeb	
Master	Victory	

The survey indicated that farmers sprayed more frequently during the major than the minor season. Climate conditions such as high relative humidity and frequent rainfall in some parts of the year render pesticides ineffective as pesticides on the surface of leaves might be washed away. Time of spraying is essential since it also affects the efficacy of the chemicals. About 45% of farmers usually sprayed early in the morning, 12% in the evening, and 39% either in the morning or evening and the remaining 4% sprayed at any time of the day.

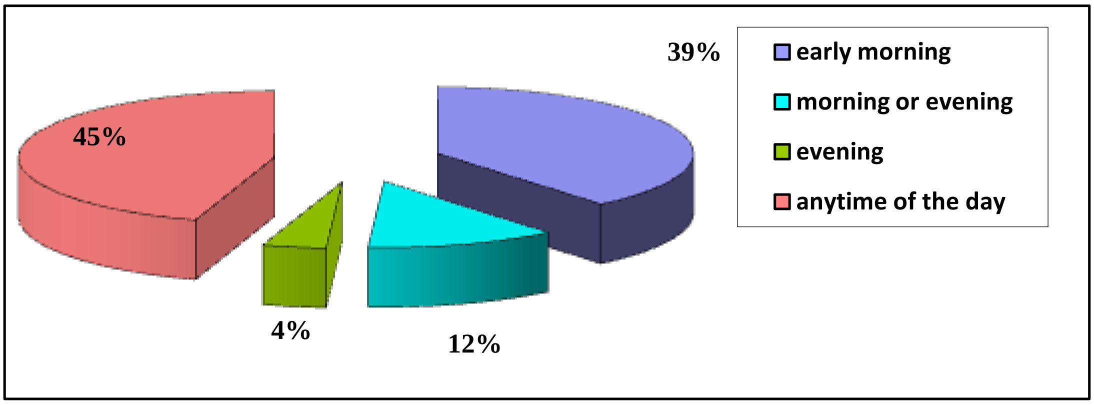

Fig. 4.5 Time of spraying of chemicals

4.6.2 Spraying frequency and pre-harvest intervals

Most (85%) farmers sprayed their crops throughout the growth period till harvest. The interval range from every three days, twice a day, every week and every two weeks being the maximum duration at which these chemicals were applied. About 15% of the farmers applied chemicals after emergence or during transplanting and subsequently sprayed on the presence of an insect or a disease attack. Generally, farmers perceived that short spraying intervals served as preventive measures.

Okra farmers mostly harvested at 3 days intervals but the overall pre-harvest interval ranged from three (3) days to 3 weeks after spraying.

4.6.3 Knowledge on correct quantity of pesticides to apply

Vegetable crop farmers interviewed mostly received information on pesticides from the Agricultural Extension Agents before applying the pesticides. Table 4.8 shows that 34% of farmers indicated that their knowledge on the precise quantity was obtained from MoFA staff, 31% from pesticide dealers and 6% of framers obtained information from fellow farmers.

Table 4.8: Knowledge on correct quantity of pesticides to apply

Sources of Knowledge	Frequency	Percentage (%)
MoFA Staff	32	34
Pesticide dealer	29	31
Label of container	28	29
Other farmers	6	6
Total	**95**	**100**

4.6.4 Effect of pesticides on human health

Majority (87%) of the 100 farmers claimed knowing the harmful effects of pesticides on human health. Some of the known effects stated by farmers included skin irritation, impaired sight leading to blindness, impotence, cancer, poisoning, heart attack and even death.

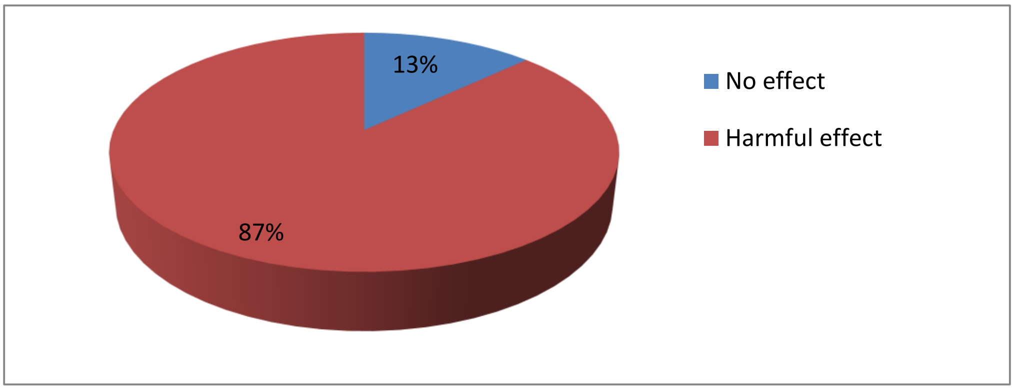

Figure 4.6: Farmers perception on the effect of pesticides on human health

In view of the harmful nature of pesticides during spraying, farmers were asked of the type of protective clothing worn when spraying. Table 4.9 indicates that more than half of the farmers interviewed were aware of the health implications of getting contaminated with the pesticides, 41% of the 95 respondents using pesticides put on a complete protective clothing (overall, wellington boots, nose mask, goggles and gloves) during pesticide application, 50% combined at least two or more protective gear to partially protect themselves while 9% wear normal clothing without wellington boots or other protective clothing.

Table 4.9: Protective clothing worn during spraying

Type of protective clothing	Frequency	Percentage (%)
Overall and wellington boots	19	20
Overall/Wellington boots/nose mask/goggles/gloves	28	30
Overall,wellington boots, nose mask,goggles,gloves (all)	39	41
None	9	9

4.6.5 Labour and pesticide application

All the farmers used knapsack sprayers to apply pesticides. The farmers used various volumes of insecticides and quantities of fungicides with 15litres of water per knapsack when applying pesticides to their vegetable crop. In terms of pesticide application, about 84% applied the pesticides by themselves, 11% hired the services of skilled labour whiles 5% performed both self application and the services of skilled labour (Table 4.10).

Table 4.10: Source of labour for pesticide application

Response	Frequency	Percentage (%)
Self	80	84
Skilled labour	10	11
Self and skilled labour	5	5
Total	**95**	**100**

4.6.6 Disposal of pesticide containers

After spraying, the common practice by farmers was to burn, burry, throw away or leave empty pesticide containers in their farms. About 17% of the farmers burry the empty pesticide containers, 35% burn, 25% leave containers on the farm and 10% throw them away. About 8% of the farmers either burn or bury while 5% burn or leave on farm (Table 4.11).

Table 4.11: Disposal of pesticide containers by farmers

Disposal of pesticide containers	Frequency	Percentage (%)
Bury	16	17
Burn	34	35
leave on farm	25	25
throw away	10	10
bury or burn	7	8
burn or leave on farm	4	5

4.7 Insecticide residues in okra

The chemical compounds detected in the sampled okra produce and their residual levels are shown in table 4.12. Fenitrothion and Endrin residues were detected in the okra fruit analysed from Weija. Detected compound analysed from okra sample from Ashaman was Endrin. Fenvalerate, P,P'-DDE, Profenofos, Endrin and Alpha-Endosulfan residues were identified in the okra samples analyzed from Atomic Energy. Fenvalerate, P,P'-DDE, Methamidophos, Endrin, Lambda-cyhalothrin and Alpha-Endosulfan residue levels were detected in the okra samples analyzed from Dawenya.

The limit of Detection (LOD) for organochlorines, organophosphorus and synthetic pyrethroids were 0.005 mg/kg, 0.010 mg/kg and 0.010 mg/kg, respectively. These were within minimum allowable range harmless to human health. Samples of okra from Weija, Ashaman, Atomic and Dawenya were within their various MRLs.

Table 4.12: Detected compounds on Pesticide Residue Analysis of Okra

Test Code	Tests Conducted	Location	Unit	Results	Specification (EU MRLs for okra
AEN	Alpha-Endosulfan	Atomic, Dawenya	Mg/kg	<0.01	0.05
END	Endrin	Weija, Atomic Ashaiman, Dawenya	Mg/kg	<0.01	0.01
FEN	Fenitrothion	Weija	Mg/kg	<0.01	0.01
FEV	Fenvalerate	Atomic, Dawenya	Mg/kg	<0.01	0.02
Lambda-cyhalothrin	Alpha-Endosulfan	Dawenya	Mg/kg	<0.01	0.03
MEH	Methamidophos	Dawenya	Mg/kg	<0.01	0.01
PDE	P,P'-DDE	Atomic, Dawenya	Mg/kg	<0.01	0.05
PRO	Profenofos	Atomic	Mg/kg	<0.01	0.05

Source: Laboratory test results, GSA, 2012

CHAPTER FIVE

DISCUSSION

5.1 Farmers demographics and farming characteristics

The results obtained from field survey indicated that the literacy rate of the farmers was low. Most of the farmers had only up to Junior High School education (50%), typical of educational status of farmers in developing countries like Ghana (WHO, 2000). Their source of information is most often augmented by extension personnel from Ministry of Food and Agriculture especially with regards to their farming practices. Nevertheless, the presence of senior high school and tertiary education among the farmers improved the effectiveness of farmer to farmer knowledge sharing. Due to lack of education and training on record keeping, farmers do not keep records on their farming operations such as the quantity of fruit harvest and postharvest losses incurred. They also did not follow the recommended dosage and applied pesticides at any stage of the crop.

Ngowi (2003) reported that years of experience in farming could increase productivity and a better understanding of farming activities. Due to limited land most of the farmers engaged in small scale farming. Farm sizes ranged between 1 to 2 acres or 0.4 to 0.8 ha, the acreage cropped in the dry season is usually very small (MoFA, 2011). Vegetable crops grown included both local and exotic varieties to meet market demands typical of urban markets with varying demand for different types of vegetable crops.

5.2 Source of Planting Materials

Decisions on seed source are shaped by price and perceived quality. Farmers will not invest in off-farm seed if the costs are high. Farmers using their own seed do not incur transaction costs (Bockari-Kugbei, 1994; Tripp, 1997). About 42% of the farmers obtained their seeds from certified seed shops; 24% used their own seeds while 18% acquired seeds from friends. It had been reported that most farmers in Sub-Saharan Africa do not buy seeds but they save their own or obtain them from other farmers. The major reasons assigned to this situation are agronomic and economic viz: the saved variety is the best suited to the local soil and climate and it saves money (Anon., 2001).

5.3 Harvesting of vegetable crops

About 72% of farmers usually harvested their vegetable crops either in the morning or evening or both. Thompson (2005) stated that harvesting should be done during the coolest time of the day, which is usually in the early morning. Thompson (2005) also said the produce should be handled gently to prevent skin breaks, bruises, spots, rots, decay, and other deterioration. Successful postharvest handling of vegetable crops requires careful coordination and integration of the various steps from harvesting operations to consumer level in order to maintain the initial product quality (Sargent *et. al.*, 2007). Sharma and Singh (2000) and Kader (2002) reported that harvesting practices determine the extent of variability in maturity and physical injuries. Physical injuries lead to accelerated loss of water and vitamin C and increased susceptibility to decay by fungi or pathogens during storage.

Harvesting is done manually; hence the harvesters have a major influence on produce quality (Acedo, 2010). According to a report by Statistics, Research and Information

Directorate (SRID), MoFA, (2011), the main system of farming in Ghana is traditional. In the survey, about (75%) of the respondents employed mostly visual observation and about (7%) used hand feel of produce to determine the maturity of vegetable crops before harvesting. According to Egyir *et. al.*, (2008) most growers decide when to harvest by looking and sampling fruits based on sight-colour, size and shape, touch-texture, hardness or softness, smell-odour or aroma, taste-sweetness, sourness, bitterness and resonance-sound when tapped.

Farmers stated that there was little mechanized farming and the main farming tools are hoe and cutlass, but bullock farming is practiced in some places, especially in the North. From the study the manual methods of harvesting vegetable crops were the use of knife, cutlass, blade and hand twisting. Tomato, egg plant and pepper were often hand twisted; cabbage by the use of cutlass or hand twisting and okra was harvested using knives or blade.

Farmer usually sorted or graded harvested produce using parameters such size, colour, shape, physical blemish, weight and texture of fruit (firmness). Sorting is usually done to separate poor produce from good produce (Bautista and Acedo, 1987). Sorting or grading coupled with appropriate packaging and storage, will extend shelf life, maintain wholesomeness, freshness, and quality, and substantially reduce losses and marketing costs.

5.4 Storage and marketing of vegetable crops

Storage as applied to fresh fruit and vegetable crops is defined by the FAO (2000) as holding fresh fruit and vegetable crops under controlled condition. According to Kader (2002), if produce is to be stored, it is important to begin with a high quality product.

However, farmers do not have adequate storage facilities to reduce losses. There is also the lack of capital to enable farmers to acquire and use cold storage facilities even when available. Many growers depend on almost daily sales for their incomes and hence may not store their produce. This may be true since majority of farmers interviewed did not store produce but send them to the market after harvesting.

The processed peppers were stored between 3 months to a year. Unavailability of ready market caused 7% of farmers to send their produce to the market immediately after harvest or the next day. The vegetable crops grown are sold on the local market and exported as well.

5.5 Pest and disease problems

About 99% and 79% of respondents interviewed respectively encountered pest and disease problems. According to MoFA (2011), several insect pests and diseases attack cabbage, pepper, okra, egg plant and tomato.

Aphids, whiteflies, diamondback moth and grasshoppers were the most devastating insect pests identified by farmers. Biney (2001) also reported that tomato farmers identified the variegated grasshopper, aphids, whiteflies and mole crickets among their pests. The whitefly, *Bemisia tabaci* prior to 1990 was not recorded in any Ghanaian publication as a pest of vegetables; however, it is now reputed to be the most important insect pests of vegetables in the country (Obeng- Ofori, 1998). They have become important due to the misuse of insecticides on tomatoes, cabbage, okra and peppers (Critchley, 1995). Both farmers and retail traders described the nature of loss in terms of weight loss, presence of insects, and destruction by rodents/birds, rotting of fruits, wilting and shrinking, microbial or disease infection, spillage and boring by insects.

5.6 Estimated post harvest losses at farmer and trader levels

Postharvest losses vary greatly among commodities and production areas and seasons. In the United States, the losses of fresh fruit and vegetable crops are estimated to range from 2- 23%, depending on the commodity, with an overall average of about 12% losses between production and consumption sites (Cappellini and Ceponis, 1984).

For farmers, postharvest loss was quantified and calculated as a percentage based on total harvested produce. For retailers, loss was estimated as the difference between quantity purchased and quantity sold in relation to total quantity purchased. To obtain a value of loss experienced, actual loss per unit was multiplied with the prevailing selling price (Abdullah, 2002).

Loss data also varies because of different methods used to assess losses and the methods are rarely reported (Anonymous, 2006; Kader, 2002). About half of the losses are due to physical injuries and improper handling during storage, and distribution (Cortez, 2002). An estimated post harvest loss of highly perishable produce such as fruit, vegetable crops and root crops in developing countries can be as high as 50% (Thomas, 2005)

Farmers and traders both incurred post harvest losses during postharvest handling of vegetable crops. As much as 600 heads of cabbage were lost in an average of 3100 heads harvested. Such loss does not only affect farmer income but nutritional status of the average Ghanaian. A fifth of tomato goes waste in the hands of the farmers indicating huge post harvest loss before it gets in the hands of the trader and then the consumer. Over 10% of losses were recorded in pepper and okra. The estimated loss in egg plant though minimal cannot be undervalued in view of its nutritional and economic value.

Similarly, a survey conducted by Egyir *et. al.*, (2008) showed an overall loss level of 15 percent estimated for vegetable crops with approximately 21 percent and 14 percent estimated loss of tomato and onion respectively in the major season. They also reported an estimated loss percentage of 30% and 13% in the minor season. Vegetable crops losses occurred most during harvesting, transportation, storage and grading and sorting.

Using household consumption as a basis for categorization, a 2009 nation-wide Food Security and Vulnerability Analysis of Ghana confirmed that there are currently 1,200,000 million food insecure people in Ghana and an additional 2,007,000 vulnerable to food insecurity. It is the poor that are most vulnerable to food insecurity. All households in Ghana rely on the market to some degree to meet their food needs. However, a significant proportion of Ghanaian households in rural and urban localities produce some of the food they consume. For these households, hunger is frequently associated to lack of food due to postharvest losses (MoFA, 2007).

From the results, about 15-20% or more of postharvest losses were incurred in the target vegetables except egg plant which had a substantially lower loss due to its hardness and low moisture content. If such losses are reclaimed by means of proper postharvest management, it will not only help in solving the food security problems but will also improve the health and income of farmers. Such high postharvest loss requires urgent measures by government and all stakeholders concerned.

Some strategies proposed to reduce postharvest losses in vegetable crops include:

- Harvesting of produce at proper maturity stage
- Rough handling should be avoided to reduce physical damage
- Suitable packaging should be introduced to reduce all types of physical damage
- Markets should be improved by building appropriate market stalls with storage facilities and proper ventilation
- The farmers and traders should be educated on proper packaging, packing and handling techniques
- The public should be encouraged to accept processed agricultural products. This will reduce the percentages of losses that occur between transporting to the market by farmers, wholesalers and retailers.
- The use of appropriate postharvest management procedures that will slow down deterioration and maintain quality and safety of the commodities.

Kader (2002) argued that it is impossible and uneconomical to completely eliminate postharvest losses but it is possible and desirable to reduce them by 50%. Minimizing postharvest losses of food that has already been produced is more sustainable and environmentally sound than increasing production areas to compensate for these losses.

5.7 Pesticide use pattern of vegetable farmers in Ghana

In general, pest pressure was more pronounced in the major wet season than in the minor wet and the dry seasons. Chemical pesticides were the most important agents for controlling pests and diseases (Gerken *et. al.,* 2001). Dinham (2003) estimated that 87% of farmers in Ghana use chemical pesticides to control pests and diseases on vegetable crops. In the present study about 95% of the farmers applied chemical pesticides to control pests and diseases. The farmers assumed that the only solution to pest is to spray frequently. Pesticides used in agriculture in tropical countries like Ghana had been instrumental in reducing crop losses both before and after harvest (Clarke *et al.,* 1997). The high dependence on pesticide by these farmers is an indication that they are not aware of other pest management strategies that are effective, inexpensive and yet friendly to the environment. Pest management strategies include intercropping (Abate *et al*. 2000), proper tillage type, crop rotation and the use of biological pesticides such as neem and Bt.

Most commonly used pesticides are insecticides, fungicides and herbicides. Insecticides were the most used because insect pests were the most serious problem in vegetable production in the study area. This was followed by fungicides usage, indicating that fungal attacks ranked second to insect pests. Herbicides were least in use probably because weeding could easily be done manually by deploying community members. A survey conducted in vegetable growing areas in Ghana identified lindane, unden, karate and dithane as the most used pesticides by vegetable growers (Amengor and Tetteh, 2008).

A study by Amoako (2010), indicated that thirty-eight (38) out of the forty-nine (49) farmers interviewed, representing 77.6% sprayed in the mornings (6am-11am). The remaining eleven (11) farmers, representing 22.4% sprayed in the evenings (4pm-6pm). None of the farmers sprayed in the afternoons (12noon-3pm). According to Jiang and Pearce, (2005) research has shown that vegetables harvest time of day could affect quality. In general, harvesting during the coolest time of the day (e.g. early morning) is desirable therefore the time of the day when harvesting is done also affects produce quality and shelf life. However, harvesting later in the day has an added advantage because sugar levels were found to be higher as a result of photosynthesis during the day (O'Hare *et al*., 2001).

5.8 Use of protective clothing

The need for complete protective clothing when spraying cannot be over emphasised (Rosenberg, 1990). The main protective materials mentioned by the farmers were the following: long sleeved shirts, long trousers, wellington boots, gloves, goggles, overall, and nose mask. About 9% of the farmers did not use personal protective clothing during spraying of pesticides. Their reasons were that the protective clothing was expensive and are uncomfortable to use under the prevailing hot and humid climatic conditions. This confirms the findings of Clarke *et al.*, (1997).

According to Kumar (2007), some health effects of pesticides include, chronic liver damage, cirrhosis and chronic hepatitis, endocrine, immune suppression, cytogenic effects, polynuritis, blood dyscariasis, allergic dermatitis, lung cancer, and kidney infection. It also has chronic neurobehavioural effects like persistent headaches, blur vision, unusual fatigue or muscle weakness, and problem with mental functions including memory, concentration, depression and irritability.

There is the need to encourage farmers to put on appropriate protective clothing when spraying pesticides. Health and environmental problems cannot be isolated from economic concerns due to the fact that incorrect pesticide use results not only in actual yield loss but also in health, air and water pollution. The problems of farmers' health should be an important concern for policy makers when addressing the economic efficiency of crops.

Earlier studies by Aghasi *et al.,* (2010), revealed that farmers who use pesticides without full understanding of their impact on human health and the environment risk not only their health but the economic stability of their family at large. Humans get into contact with pesticides, through pesticide application, weeding, pruning, harvesting, and residues in vegetable crops or in house spraying to kill mosquitoes, cockroaches, fleas and flies. Storing pesticides may lead to acute and/or chronic exposures, with adverse health implication in developing countries. Aghasi *et. al.,* (2010) further argued that although the inhalation, dermal and oral routes of exposure are the most common, pesticide residues in food and water may add to indirect exposures common in the general population. Ill health may affect the overall performance and the productivity of the family farm since labour input in agriculture is normally supplied by households especially in small-holder agriculture in developing countries (Ajayi, 2000).

A 2008 study of vegetables farmers in southern and central regions of Ghana, conducted for the US-based International Food Policy Research Institute, found that 69 per cent farmers surveyed had experienced burning sensations on their skin, 47 per cent had experienced headaches after application, 39 per cent reported itchy or watery eyes and third had experienced both dizziness and breathing difficulties. Around 28 per cent of farmers stated that they had sought medical attention at least once (Horna *et al.*, 2008).

Aside the health risk involved with pesticide use, the manner in which farmers dispose insecticides and their packages can have personal, public and environmental health implications (Clarke, 2008).

5.9 Knowledge on correct quantity of pesticides

The Agricultural Extension Agents of the Ministry of Food Agriculture (MoFA) provide farmers with the technical knowledge on the application of pesticides. The Ghana Agricultural Association Business Information Centre (GAABIC) organise periodic training programmes for agricultural input dealers concerning pesticides use among other farming practices. Such input dealers in turn pass on this knowledge to farmers when making purchase of inputs such as pesticides. Knowledge of the right quantity of pesticide to use through input dealers represents about 31% of farmers interviewed.

The survey revealed that farmers did not follow the recommended application rate by manufactures as reported by other workers (Biney, 2001). Yen *et al.,* (1999) reported that application rates exceeded manufacturers' recommendation as well as the recommended pre-harvest intervals after pesticide application. Most farmers' sprayed chemicals throughout the growing season, between 3 days to 2 weeks interval. A similar study on cabbage conducted by Amoako (2010) showed that the frequency of spraying depended on the type and the dosage of pesticides used. Those who used recommended pesticides and right dosage prescribed by agricultural extension agents for controlling insect pests in their cabbage fields applied pesticides less frequently (1-2 weeks interval) than those who used non recommended pesticides who sprayed more frequently (3-4 days interval).

According to Asante and Ntow (2009), farmers often sprayed hazardous insecticides like organophosphates and organochlorines up to five or more times in a cropping season when perhaps two or three applications may be sufficient

5.10 Pesticide residues in okra

Insecticide residues in okra were within the EU various maximum residue limits (MRLs). MRLs are established for three key reasons: to ensure that the residues on food do not pose an unacceptable risk for the health of consumers, that pesticides are used in accordance with the authorised uses, respecting the label instructions and to avoid trade barriers (European Food Safety Authority, 2009).

These MRLs detected in the okra fruits implied that even though most farmers do not follow required procedures they put mechanisms in place to ensure that the vegetable crops are safe for human consumption. This is not surprising as data gathered from the farmer survey showed knowledge in pesticide application due to training from MoFA staff and pesticide dealers. Farmers experience in farming could also play a functional role in achieving this result.

Insecticides detected in the study included Alpha-Endosulfan, Endrin, Ethoprophos, Fenitrothion, Fenvalerate, Alpha-Endosulfan, Methamidophos, P,P'-DDE and Profenofos. Chahal *et. al.*, (1992) investigated the persistence of residues of endosulfan and fenvalerate on okra and found that the residue took 1-3 days to become safe for consumption. This may explain why okra farmers harvested every 3 days after spraying.

Similarly analysis for pesticide residue on lettuce leaves conducted from 9 major markets and 12 specialized selling points in 3 major Ghanaian cities namely Accra, Kumasi and Tamale detected Chlopyrifos (Dursban) on 78% of the lettuce, lindane (Gamalin 20) on 31%, endosulfan (Thiodan) on 36%, lambdacyhalothrin (Karate) on 11%, and dichloro-diphenyl-trichloroethane on 33%. Most of the residues recorded exceeded the maximum residue limit for consumption (Amoah *et. al.,* 2006).

Work already done in some farming communities in the Ashanti Region of Ghana and some other countries indicated the presence of organochlorine pesticide residue in fish (Osafo and Frimpong, 1998), vegetables, water sediments, mother's milk and blood samples (Ntow, 2001). Since these chemicals are toxic to living organisms, increased accumulation in the food chain may pose serious health hazards to the general populace (Jayashree and Vasudevan, 2007).

EFSA (2009) explained that in most cases the MRLs are well below the toxicologically acceptable residue levels. Thus, if a pesticide residue is found on a given crop at or below the MRL, then the crop can be considered safe for the consumer’s health. EFSA (2009) further pointed up that if a residue exceeds the MRL, it is not necessarily true that the consumer is at risk. In the latter case, an estimation of the expected exposure and a comparison with the toxicological reference values is necessary to assess if the food poses a consumer health risk.

Although the residues were below the MRLs, there is still a need to monitor and control their usage in view of its toxicity to humans and possible contamination in food commodities (Biney, 2001).

CHAPTER SIX

CONCLUSION AND RECOMMENDATIONS

6.1 CONCLUSIONS

Vegetable crops are increasingly becoming important as produce for domestic and export markets. They have a great potential to improve the nutrition and thereby the health of consumers as most are good sources of vitamins, minerals and proteins needed for the proper functioning and development of the human body. Postharvest loss in vegetable crops is a major problem with both farmers and traders. Losses were as high as 20% for tomato. Trader postharvest quantity losses ranged from 10-15% except with egg plant in which the loss was insignificant. The principal causes of losses were physiological deterioration, mechanical and pathological damage. Majority of farmers interviewed used chemical pesticides in their farming activity. Many farmers use protective clothing when spraying to avoid contamination. Knowledge on quantities of pesticides to be applied is obtained from MoFA staff, input dealers, and ability to read labels on pesticides containers and with the help of colleague farmers.

Laboratory analysis of okra samples from the four selected locations (Ashaiman, Weija, Dawenya and Atomic) were within their Maximum Residue Limits (MRL'S). Vegetable crops that find its way to the market are within their Maximum Residue Limits (MRL'S) hence safe for human consumption.

6.2 RECOMMENDATIONS

Based on the findings of the study, the following recommendations are made.

1. The Ministry of Food and Agriculture (MoFA) through its extension staff must intensify the provision of training for farmers on postharvest handling and management to reduce losses. Farmers must also be educated on record keeping in order to keep account of farming activities.
2. Metropolitan, Municipal and District Assemblies and other stakeholders must provide suitable storage and physical market structures to traders in order to reduce postharvest losses.
3. Periodic education, training and information dissemination activities on pesticides and their effects on health must be given in all the farming communities in the country, especially communities noted for the production of vegetable, fruit and other food crops. This would help minimize the mishandling and misuse of pesticides which is becoming a health threat to both consumers and growers
4. Sanctions must be implemented to ensure that farmers wear protective clothing when spraying pesticides due to their harmful nature.
5. Stakeholders such as the Ministry of Food and Agriculture, EPA and Associations of Agrochemical dealers must form a common platform to combat the importation and smuggling of banned pesticides into the country
6. MoFA in collaboration with Ghana Standards Authority must carry out periodic residue analysis on vegetable crops that are sold in the market to ensure that residues are within their Minimal Residual Limit's.
7. Further study should be carried out in other parts of the country as well as during the major season. Insecticide residue analysis should be conducted on the other vegetable crops grown in Ghana.

8. There is the need to promote good harvesting and postharvest management as well as technology that minimizes losses at both farmer and trader ends.

REFERENCES

Abate, T., Van Huis, A. and Ampofo, J.K.O. 2000. Pest management strategies in traditional agriculture: An African perspective. *Annual Review of Entomolology* 45: 631-659.

Abdelgadirand, E.H. and Adam, S.E.I. 2011. Effect of various levels of dietary malathion on wistar rats. *Journal of Pharmacology and Toxicology* 6: 69-75.

Abdullah, S.S. and Farooq, U. 2002.The vegetable sector in Indochina Countries: Farm and household perspectives on poverty alleviation. Kingdom of Cambodia, Ali, M. (ed.), Technical Bulletin No. 27. Shanhua, AVRDC, pp. 31-73.

Acedo, A.L. Jr. 2010. Postharvest technology for leafy vegetables. AVRDC-ADB Postharvest Projects RETA 6208/6376, AVRDC Publication No. 10-733, AVRDC - The World Vegetable Center, Taiwan, 67pp.

Adhikari, S. 2010. Bioremediation of malathion from environment for pollution control. *Research Journal of Environment and Toxicology* 4: 147-150.

Aghasi M., Hashim Z., Moin S., Omar D. and Mehrabani M. 2010. Socio-demographic characteristics and safety practices in pesticide applicators in Zangiabad Area, Iran. *Australian Journal of Basic and Applied Sciences* 4(11): 5689-5696.

Ajayi, O.C. 2000. Pesticide use practices, productivity and farmer's health: The case of cotton-rice systems in Cote d'Ivoire, West Africa. Hannover, Germany: A publication of the Pesticide Policy Project (Special Issue Publication Series, No. 3, 172 pp.

Al-Eed, M.A., Abo-El-Saad, M. and Al-Faiyz, Y. 2006. Residues and decay of some insecticides in different types of water. J*ournal of Applied Science* 6: 1833-1837.

Al-Wabel, M.I., El-Saeid, M.H., Al-Turki, A.M. and Abdel-Nasser, G. 2011. Monitoring of pesticide residues in Saudi Arabia agricultural soils. *Research Journal of Environment and Science* 5: 269-278.

Armah, A. F. 2011. Assessment of Pesticide Residues in Vegetables at the Farm Gate: Cabbage (*Brassica oleracea*) Cultivation in Cape Coast, Ghana. *Research Journal of Environmental Toxicology, 5: 180-202.*

Amengor G. M. and Tetteh F. M. 2008. Effect of pesticide application rate on yield of vegetables and soil microbial communities. *West African Journal of Applied Ecology*, Vol. 12. *CSIR-Soil Research Institute, Academy, Kwadaso, Kumasi, Ghana.*

Amoah, P., Drechsel, P., Abaidoo, R. C., Ntow, W.J. 2006. Pesticide and Pathogen Contamination of Vegetables in Ghana's Urban Markets. *Archives of Environmental Contamination and Toxicity* 50, 1-6 pp.

Amoako, P.K. 2010. Assessment of pesticides used to control insect pests and their effects on storage of cabbage *(Brassica Oleracea Var Capitata)* - A case study in Ejisu Juaben Municipal Area, KNUST, pages 1-2

Andrew, R. and Simon, C.1998. Pesticide residues in raw fruit and vegetables and fruit juices. Health Services - Food Survey Reports 1996-97. Also available: http://health.act.gov.au/c/health.

Andrews, J. 1995. Peppers: The domesticated Capsicum. 4th edition. University of Texas Press, Austin, TX. 170pp.

Anonymous. 2006. Singapore to implement new cold chain standards. ColdStoreDesign.comNewsletter. Available at http://newsletter.coldchainexperts.com/August06/CCEAugust.htm

Anonymous. 2004. Annual report of National Horticulture Board, India August, 51 pp.

Anonymous. 2001. '*North Dakota organic farmers worry about biotech contamination'*. Cropchoice News. Also available at http://www.cropchoice.com/leadstry8b5a.html?recid=232

Asante, K. A. and Ntow W. J. 2009. *Council for Scientific and Industrial Research - Water Research Institute (CSIR WRI)* - Status of Environmental Contamination in Ghana, the Perspective of a Research Scientist, pp. 1-8

Awuti, K. 1971. Tomato cultivars suitable for dry season on the Accra plains. *Ghana Journal of Agriculture Science* 4:113-115.

Baldwin, B. 1995. The history of cabbage. Department of Plant Sciences, University of Saskatchewan. Available at http://www.gardenline.usask.ca/veg/cabbage.html.

Barkat, A.K. 2005. Studies on the residues of commonly used insecticides on fruits and vegetables grown in NWFP-Pakistan, Department of Agricultural Chemistry Faculty of Nutrition Sciences, Pakistan 213pp.

Bartz, J.A. and Brecht, J.K. 2002. Postharvest physiology and pathology of vegetables. 2nd edition, Marcel Dekker, New York. 744pp.

Bautista, O.K. and Acedo, A.L. Jr. 1987. Postharvest handling of fruits and vegetables. Manila: National Book Store Inc. Techguide Series No. 4. 24 p.

Biney, P. M. 2001. Pesticide use pattern and insecticide residue levels in Tomato (*Lycopersicum esculentum)* in some selected production systems in Ghana. *Mphil Thesis*, University of Ghana Legon, Ghana 127pp.

Blay, E. T. 1978. Improvement on Solanaceous crops in Ghana. Procedings Symposium of Crop Improvement in Ghana. University of Ghana. Legon, Ghana.

Bockari - Kugbei, S.M. 1994. The role of small-scale enterprises in African seed industries. Doctor of Philosophy Thesis, Department of Agricultural Economics, University of Reading, UK.

Boobis, A.R., Ossendorp, B.C., Banasiak, U., Hamey, P.Y., Sebestyen, I. and Moretto, A. 2008. Cumulative risk assessment of pesticide residues in food. *Toxicology Letters* 180: 137-150.

Camargo, G., and Perdas, A. 2002, Agrianual, Anuário da Agricultura Brasileira, 41.

Cappellini, R.A. and Ceponis, M.J. 1984. Postharvest losses in fresh fruits and vegetables. *In:* Moline, H.E. (ed.), Postharvest pathology of fruits and vegetables: postharvest losses in perishable crops, University of Califonia Bulletin, p 24-30.

Chahal K. K., Singh B., and Singh P. P., 1992. Persistence of endosulfan and fenvalerate on okra fruits. India. Ecol.19 (2): page 197

Choudhury, M.L. 2006. Recent developments in reducing postharvest losses in the Asia-Pacific region. Postharvest management of fruit and vegetables in the Asia-Pacific region, APO, ISBN: 92-833-7051-1

Choudhury, M.L., Susanta, K.R. and Kumar, R. 2004. Recent developments in reducing postharvest losses in the Asia-Pacific region. Proceedings of the APO Seminar on Reduction of Postharvest Losses of Fruit and Vegetables, Clarke, E. 2008. The health dilemma of pesticide use in modern agriculture. In: Owusu, G. K. (Ed.), Ghana Science Association 25th Biennial Conference Plenary presentations. Yamens Press, Accra , Ghana; 30-6

Clarke, E.E.K., Levy, L.S., Spurgeon, A. and Calvert, I.A. 1997. The problems associated with pesticide use by irrigation workers in Ghana. Institute of Occupational Health, University of Birmingham, Birmingham, UK Occup. Mod. Vol. 47, No. 5, pp. 301-308, 1997.Copyright O 1997 Rapid Science Publishers tor SOM.

Critchley, B. R. Manual for integrated pest management of diseases, insects, nematodes and weeds of garden egg, okra, onion, peppers and tomato in Brong Ahafo, Ghana. National Resource Institute, Chatham Maritime, UK. 1995: 65pp.

Codex Alimentarius Commissssion 2009. Pesticide residues in food and feed, glossary of terms. Also available: www.codexalimentarius.org/pestres/Glossary

Cooper, J. and Dobson, H. 2007. The benefits of pesticides to mankind and the environment. Crop Protection; 26(9): 1337-48.

Cortez, L.A.B., Honório, S.L., and Moretti, C.L. 2002. Resfriamento de frutas e hortaliças. Embrapa Informação Tecnológica, Brasília, DF, Brasil.

Damalas, C.A. and Eleftherohorinos, I.G. 2011. Pesticide exposure, safety issues and risk assessment indicators. *International Journal of Environmental Research* 8: 1402-141.

Danquah-Jones, A. 2000. Variation and correlation among agronomic traits in Garden Egg (Solanum gilo Radii). Department of Crop Science. Accra, University of Ghana, Legon**:** 30.

Dinham, B. 2003: Growing vegetables in developing countries for local urban populations and export markets: problems confronting small-scale producers. *Pest Managment Science* 59: 575–582.

Doubrava, N., Blake, J.H. and Williamson, J. 2004. Cabbage, broccoli and other cole crop diseases. *Clemson extension, Home and Garden Information Center*. Retrieved March 20, 2012 http://hgic.clemson.edu/factsheets/HGIC2202.htm.

Ecobichon, D.J. 2001. Pesticide use in developing countries. *Toxicology* 160: 27-33.

Edwards, C.A. 1986. *Agrochemicals as environmental pollutants In*, Control of pesticide applications and residues in food. A Guide and Directory, Van Hofsten, B. and Eckstrom, G. (ed.), Swedish Science Press, Uppsala,

European Food Safety Authority (EFSA) Scientific Report, 2009. Pesticide Residues according to Article 32 of Regulation (EC) No 396/20051. Prepared by Pesticides Unit (PRAPeR) 305, 1-106pp

European Union 2012. EU legislation: Maximum Residue Levels (MRLs) of pesticides in food. CBI Ministry of Foreign Affairs of the Netherlands.

Egyir, S. Irene, Sarpong, D. B. and Obeng-Ofori, D. 2008. Final report on harvest and postharvest baseline study. University of Ghana Legon, Ghana, Department of Agricultural Economics and Agribusiness.

El-Nahhal, Y. 2004. Contamination and safety status of plant food in Arab countries. *Journal of Applied Science* 4: 411-417.

Environews Forum. 1999. Killer environment. Environ Health Perspectives. 1999; 107:A62. [PMC free article] [PubMed].

Environmental Protection Agency 2012. Revised Register of Pesticides as at 30th November 2012 under Part II of the Environmental Protection Agency Act, 1994 (Act 490)

Eskenazi, B., Rosas, L.G., Marks, A.R., Bradman, A. and Harley, K. 2008. Pesticide toxicity and the developing brain. *Basic Clinical Pharmacology and Toxicology* 102: 228-236.

Essumang, D. K.; Dodoo, D. K.; Adokoh, C. K.; Fumador, E. A. 2008.Analysis of Some Pesticide Residues in Tomatoes in Ghana Human and Ecological Risk Assessment: *An International Journal* , Volume 14 (4): 796-806.

Farag, R.S., Abdel Latif, M.S., Abd El-Gawad, A.E. and Dogheim, S.M. 2011. Monitoring of pesticide residues in some Egyptian herbs, fruits and vegetables. *International Journal of Food Research*, 18: 646-652.

Food and Agriculture Organization 2000. Twenty second Regional Conference for Europe: Food safety and quality as affected by organic farming, Porto, Portugal 24-28.

Food and Agriculture Organization of the United Nations (FAO) 2011. Global food losses and food waste; extent, causes and prevention.

Food and Agriculture Organization of the United Nations 2011. FAO Statistics Database. Retrieved 2013-01-23 from www.wikipedia.org/wiki/Cabbage.

Food and Agricultural Organization of the United Nations (FAO) 2009. www.faostat.fao.org. Accessed Aug. (2012).

Food and Agricultural Organization of the United Nations (FAO) 2007. FAOSTAT. FAO. Retrieved May, 2012.

Gerken, A; Suglo, J.; Braun, M. 2001. An economic and institutional analysis of current practice and factors influencing pesticide use. A Publication of the pesticide policy project, Hannover. This can also be found at www.ifgb.unihannover.

GhanaDistrict.com from www.wikipedia.org/wiki/Districts_of_Ghana. Retrieved on December 18, 2011.

Ghana Export Promotion Authority (GEPA)/ Data Collection Department, 2012

Ghana Statistical Service (GSS) 2012. *2010 Population and Housing Census, summary report of final results.* Accra, Ghana: Ghana Statistical Service.

Gleason, Mark L. and Edmunds, Brooke A. (2006). Tomato diseases and disorders. Retrieved February 15, 2013, from www.store.extension.iastate.edu

Handa S.K., Agnihotri N. P. and Kulshrestha G. 1999. Pesticide Residues: Significance, Management and Analysis, Research Periodicals and book publishing home; Texas, USA

Hanson, R., D.K. Dodoo and D.K. Essumang, 2007. The effect of some selected pesticides on the growth and reproduction of fresh water oreochromis niloticus, chrysicthys nigrodigitatus and clarias griepings. *Bull. Environmental. Contamination. Toxicology*, 79: 544-547pp.

Harris, J. Linda, 1998. Peppers: Safe method to store, preserve and enjoy. Department of Food Science and Technology, University of California, Davis, 13pp.

Harris, K.L. and Lindblad, C.J. 1978. Postharvest grain loss assessment methods. Minnesota, America Association of Cereal Chemist, pp. 193.

Hodgson, E., Cope, W. Gregory and Leidy, Ross B. 2004. Classes of Toxicants: Use Classes In *A Textbook of Modern Toxicology 3rd edition*, ISBN 0-471-26508-X. John Wiley & Sons, Inc. pp 49-78.

Hogstedt, C. 1992. Pesticides. In: JeyaratnamJ, ed. *Occupational Health in Developing Countries*. Oxford University Press. 242-243.

Horna, D., Smale, M., Al-Hassan, R., Falck-Zepeda, J., and Timpo, S.E. 2008. 'Insecticide use of vegetables in Ghana: Would GM seed benefit farmers?', *IFPRI Discussion Paper*, p.10

Horna, D., Timpo S., Al-Hassan R. M., Smale M. and Falck-Zepeda J. 2007. Vegetable production and pesticide use in Ghana: Would GM varieties have an impact at the farm level? AAAE Conference proceedings 473-477. Available at http://ageconsearch.umn.edu/bitstream/52182/2/Horna.pdf). Accessed 05/09/2012

Horna, D. Smale, M. and Falck-Zepeda, J. 2006. *Assessing the Potential Economic Impact of Genetically Modified Crops in Ghana: Tomato, Garden Egg, Cabbage and Cassava*. PBS report.

Hunziker, A. T. 2001. Genera Solanacearum: The genera of *Solanaceae* illustrated, arranged according to a new system. ARG Grantner, Ruggell.

Hurst, P.; Alistair, H.; Nigel, D. 1991. *The Pesticide Handbook*, Journeyman Press: London.

Hussain, S., Masud T. and Ahad, K. 2002. Determination of pesticides residues in selected varieties of mango. *Pakistan Nutrition Journal*. 1: 41-42.

Iya, I.B. and Kwaghe, T.T. 2007. The economic effect of spray pesticides on cowpea (*Vigna unguculata* L. Walp.) production in Adamawa state of Nigeria. *International Journal of Agricultural Resource.* 2: 647-650.

ISSER. The State of the Ghanaian Economy in 2010, Institute of Statistical Social and Economic Research (ISSER). University of Ghana, Legon, Ghana 2011.

Jaeger, P., Sergeant A., Graffham A., Orchard J., Adongo A. and Homer S. 2008. Horticulture exports from Ghana: A strategic study. Joint Departmental Discussion Paper – Issue 2 © 2011 The International Bank for Reconstruction and Development /The World Bank.

Jayashree, R. and Vasudevan, N. 2007. Effects of tween 8 added to the soil on the degradation of endosulfan by *Pseudomonas acruginosa. International Journal of Environmental Science Technology*. 4 (20): 203-210.

Jiang, T. and Pearce, D. 2005. *Shelf-life extension of leafy vegetables*: evaluating the impacts. Impact Assessment Series Report No. 32. 62 p.

Jiries, A.B.; Al Nasir, F.M.; Beese, F. 2002**.** *Water, Air Soil Pollution*, 133, 97.

Joint Expert Meeting on Pesticide Residue (2009). Available at www.firstagro.com/PDF/Codex standard Colour Capsicum.pdf. Retrieved on 01/04/2011

Joint Expert Meeting on Pesticide Residue (2009). Available at www.firstagro.com/PDF/Codex standard Tomato.pdf. Retrieved on 01/04/2011

Kader A. Adel 2006. *Assessment of post-harvest practices for fruits and vegetables in Jordan*, produced for review by the United States Agency for International Development.

Kader, A.A. 2005. *Increasing food availability by reducing postharvest losses of fresh produce*, Proc. 5th Int. Postharvest Symptoms *Acta Horticulture*. 682.

Kader, A.A. 2002, *Postharvest Technology of Horticultural Crops, 3rd ed*. Cooperational. Extension, University of California Division of Agriculture and National Resources.

Kanlayanarat, S. 2007. Postharvest technologies for fresh leafy vegetables in Thailand. Paper presented during the RETA 6376 Workshop on Best Practices in Postharvest Management of Leafy Vegetables in GMS Countries, 25-27pp

Kidd and James, 1991. The Agrochemical Handbook, The Royal Society of Chemistry, 3rd edition.

Kitinoja, L. 2002. Making the Link: Extension of Postharvest Technology pp. 481-509. In *Postharvest Technology of Horticultural Crops* (3rd edition). Kader, A.A. Technical editor. Publication 3311.

Kumar, S., Dagnoko, S., Haougui, A., Ratnadass, A., Pasternak, D. and Kouame C. 2010. Okra (*Abelmoschus* spp.) in West and Central Africa: Potential and progress on its improvement. *African Journal of Agricultural Research* Vol. 5 (25), pp. 35903598, Special Review. Available online at http://www.academicjournals.org/AJAR

Kumar, M. 2007. *Application and health effects of pesticides commonly used in India*. Unpublished PhD, Research Associate, School of Public Health, Department of

Anesthesia. Available from: http://www.eco-wes/editorial/070526.html [Accessed 24/05/2012].

Liu G.D., Simonne E.H. and Hochmuth G.J., 2012-2013. *Soil and Fertilizer Management for Vegetable Production in Florida, In:* Stephen M. Olson and Bielinski Santos (eds), Vegetable Production Handbook for Florida, University of Florida, sixth edition

Michailides, T. J. and Manganaris, G. A. 2009. Harvesting and handling effects on postharvest decay. Stewart Postharvest Review DOI: 10.2212; 5(2):1-7.

Miller, G. T. 2004. *Sustaining the Earth* (6th edition). Thompson learning Inc. Pacific Grove, California. Chapter 9. 211-216.

Ministry of Food and Agriculture (MoFA) 2011. Ghana Commercial Agriculture Project (GCAP), Pest Management Plan (PMP), Final Report November. 100pages.

Ministry of Food and Agriculture 2010. Agriculture in Ghana Facts and Figures. Statistics, Research and Information Directorate (SRID), Accra, 58pp.

Ministry of Food and Agriculture (MoFA) 2007. Food and Agriculture Sector Development Policy (FASDEP II), 77pp.

Nasr, I.N., Sallam A.A.A. and Abd El-Khair, A.A. 2007. Monitoring of certain pesticide residues and some heavy metals in fresh cow`s milk at gharbia governorate, *Egyptian Journal of Applied Science.* 7: 3038-3044.

Ngowi, A.V.F., 2003. A study of farmers' knowledge, attitude and experience in the use of pesticides in coffee farming. AFR Newsletter on Occupational Health and Safety, 13: 62.

Norman, C. and Shealy, M. D. 2007. *Illustrated Encyclopedia of Healing Remedies*. [on line] PhD. Elements Book Inc. 160 North Washington Street. Boston MA 02114. Available from: http://www.hcvn.com/healthandhealingz/kcabbage/index.htm [Accessed 17/06/2012].

Norman J. C. 1992. Tropical Vegetable Crops. Dewn: Aurthur Stock well Ltd. pp 89-95

Northern Presbyterian Agriculture Services and Partners 2012. Ghana's Pesticide Crisis: The needs for further government action, 50pp.

Nouhoheflin, T., Coulibaly, O., Andy, J., Al-Hassan, C. and Patrice Y. 2004 Consumers' perception and willingness to pay for organic vegetable in Benin and Ghana. *Shaping the Future of African Agriculture for Development: The Role of Social Scientists*.

Ntow, W.J., Gijzen, H.J., Kelderman, P., Drechsel, P., 2006**.** *Pest. Manage. Science,* 62, 356pp.

Ntow, W. J. 2001. Organochlorine pesticide in water, sediments, crops and human fluids in a farming community in Ghana. Arch. Environ. Contam. Toxicol., 40, 557 – 563pp.

Obeng-Ofori, D. and Cornelius E. W. 2008. *Post-harvest Physiology of Perishable Commodities*. College of Agriculture and Consumer Sciences, University of Ghana, Legon, Accra. 5,147-197pp

Obeng-Ofori, D., Danquah, E. Y. and Ofosu-Anim, J., 2007. *Vegetable and Spice Production in West-Africa* by the City Press Ltd.

Obeng-Ofori, D. Database on crop health problems of vegetables in Ghana. 1998: 103pp.

Obuobie, E., Keraita, B., Danso, G., Amoah, P., Cofie, O.O., Raschid-Sally, L. and P. Drechsel. 2006. Irrigated urban vegetable production in Ghana: Characteristics, benefits and risks. Accra, Ghana: IWMI, 150 pp.

Ofosu-Anim John, 2008. Post-harvest Physiology of Perishable Commodities, In: Cornelius E. W. and Obeng-ofori, D. (eds), *Postharvest Science and Technology,* College of Agriculture and Consumer Sciences, University of Ghana, Legon, Accra. pp147-196

O'Hare, T.J., Able, A.J., Wong, L.S., Prasad, A. and McLauchlan, R. 2001. Fresh-cut Asian vegetables pak choi as a model leafy vegetable. In: O'Hare, T., Bagshaw, J., Wu Li and Johnson, G.I., ed., Postharvest handling of fresh vegetables. Proceedings of a workshop held in Beijing, P.R.C., 9-11 May 2001. ACIAR Proceedings 105:113-115.

Orzolek M. D., Bogash S. M., Harsh R. M., Kime L. F. and Harper J. K., 2006. *Agricultural Alternatives: Tomato Production.* University Park: The Pennsylvania State University.

Osafo, A. S. and Frempong, E. 1998. Lindane and Endosulfan residues in water and fish in Ashanti Region of Ghana. J. Ghana Sci Assoc 1(1), pp 135-140.

Pal, R., K. Chakrabarti, A. C., and Chowdhury, A., 2006. Degradation and effects of pesticides on soil microbiological parameters-A review. International Journal of Agricultural Resource, 1: 240-258pp.

Parfitt, J., Barthel, M. & Macnaughton, S. 2010. Food waste within food supply chains: quantification and potential for change to 2050, *Phil. Trans. R. Soc.*, vol. 365, pp. 3065-3081.

Parker, B.Q., Osei, B.A., Armah, F.A. and Yawson, D.O. 2010. Impact of biomass burning on soil organic carbon and the release of carbon dioxide into the atmosphere in the coastal savanna ecosystem of Ghana. *J. Renewable Sustainable Energy*.

Power, A.G., 2010. Ecosystem services and agriculture: Tradeoffs and synergies. Philos Trans. R Soc. London B Biological Science, 365: 2959-2971pp.

Purquerio, L. F. V., A. A. Lago, F. A. Passos. 2010. Germination and hardseedness of seeds in okra elite lines. Horticultura Brasileria Brasília, 28 (2).

Purseglove J. W. 1968. Tropical Crops Dicotyledons. J.W Arrow Smith Ltd., Winter Stroke Road, Bristol 3,557pp.

Ray, R.C. and V. Ravi. 2005. Post harvest spoilage of sweetpotato in tropics and control measures. Critical Rev. *Food Science and Nutrition* 45:623-644pp.

Robert L. Metcalf, 2002. Insect Control in Ullmann's Encyclopedia of Industrial Chemistry, Wiley-VCH, Verlag GmbH, Weinheim.

Rolle, R. S. 2006. Improving postharvest management and marketing in the Asia-Pacific region: issues and challenges pp 23-31.

Romain, H. R. (2001). Crop Production in Tropical Africa. Published by Ministry of Foreign Affairs. External trade and International co-operation. Brussels, Belgium. Pp 424-430

Rosenberg J. 1990. Pesticides. In: LaDou J, ed. *Occupational Medicine.* Appleton and Lange: 401-431pp.

Ruttan, V. W. 2005. Scientific and technical constraints on agricultural production: prospects for the future. Proceedings of the American Philosophical Society. 149:453-68.

Sanborn, M., Cole, D., Kerr, K., Vakil, C., Sanin L.H. and Basil, K. 2004. Systematic review of pesticides human health effects. The Ontario, College of Family Physicians. Available: http://www.ocfp.on.ca/local/files/Communications/Current%20Issues.

Sargent, S. A., Ritenour M. A., Brecht, J. K. and Bartz, J. A., 2007. Handling, Cooling and Sanitation Techniques for Maintaining Postharvest Quality. Horticultural Sciences Department, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. Pages 97-109. Also available http//edis.ifas.ufl.edu/HS719

Sharma, R.M *and* Singh, R.R. 2000. Harvesting, postharvest handling and physiology of fruits and vegetables. *Tagore Garden, New Delhi: Industrial Publishing Co. pp* 94–147.

Simonne, E.H., W.M. Stall, S.M. Olson, S.E. Webb, and S. Zhang. 2010. Okra production in Florida. Chapter 13: 157-165.

Sinnadurai, S. 1973. Vegetable production in Ghana. Acta Hort. (ISHS) 33:25-28.

Smale, M., Zambrano, P., Falck-Zepeda, J. and Gruère, G., 2006. Parables: Applied economics literature about the impact of genetically engineered crop varieties in developing economies. EPTD Discussion Paper 158, *International Food Policy Research Institute, Washington, D.C.*

Stevens, M. F., 1991. The concentration of organochlorine pesticides in the Western Australian population, Western Australia: Health Department.

Stuart, T. 2009. *Waste – uncovering the global food scandal*. Penguin Books: London, ISBN: 978-0-141-03634-2

Sudheer, K.P. and Indira, V., 2007. Postharvest technology of horticultural crops: Vol.07. Horticulture Science Series. Forwarded by Dr. Nawab Ali.

Tanner, D., and Smale, N. 2005. Sea transportation of fruits and vegetables. An update. Stewart Postharvest Rev., 1: 1.1

Taware, S. D., 2012. Molecular studies on okra yellow vein mosaic virus (OYVMV) biotypes. University of Pune, Department of Botany, India.

Thomas, C. 2005. Postharvest Handling of Produce. Regional Agricultural Health and Food Safety Specialist, Inter American Institute for Cooperation on Agriculture (IICA),

Thompson, A.K. *(*1996). Postharvest treatments. *In:* Postharvest technology of fruit and vegetables. *Cambridge, Mass.: Blackwell Science Ltd. pp* 95–128.

Tripp, R. 1997. The Institutional conditions for seed enterprise development. Overseas Development Institute Working Paper 105

Tweneboah C.K., 1998. Vegetable and Spices in West Africa: Co-Wood publishers. Report and Recommendations on organic Farms (USDA study Team on Organic Farming US Department of Agriculture, Washington DC, 1994.

Uysal-Paha, C. and Bilisli, A. 2006. Fate of endosulphan and delmethrin residues during tomato paste production. J. Central Eur. Agric., 7: 343-348.

Wang, D. and Bosland, P.W. 2006. The genes of *Capsicum*. Horticultural Science, 41: 1169-1187.

Wang, C. H. and Liu, C. 2000. Dissipation of organochlorine insecticide residues in the environment of Taiwan, 1973-1999. J. Food Drug Anal. 8: 149-158.

Watson, W. A., Litovtz, T. L., Klein-Schwartz, W., Rodgers, G. C., Youniss, J., Reid, N., Rouse, W. G., Rembert, R. S. and Borys, D. (2003). Toxic Exposure Surveillance System. Annual Report of the American Association of Poison Control Centers. Am. J. Emerg Med. 22(5): 335-404.

Waxman, Micheal F. 1998. Agrochemical and Pesticide Safety Handbook. C RC press. U. S. A. pp120-640.

WHO, 2000. The WHO Recommended Classification of Pesticides by Hazard and Guidelines to Classification. World Health Organization, Geneva.

World Health Organization; 1990. Public Health Impact of Pesticides Used in Agriculture; Geneva, p. 88.

World Resources 1998. Disappearing food: How big are postharvest losses? available at: http://earthtrends.wri.org/features/view_feature.php?theme=3&fid=13

Yen, I.C., Bekele, I., and Kalloo, C. 1999. Use Patterns and Residual Levels of Organophosphate Pesticides on Vegetables in Trinidad, West Indies. *Journal of AOAC International VOL. 82, NO. 4.*

Zidan, N.E.H.A., 2009. Evaluation of the reproductive toxicity of chlorpyrifos methyl, diazinon and profenofos pesticides in male rats. *International Journal of Pharmacology*, 5: 51-57.

APPENDIX 1: QUESTIONNAIRE TO FARMERS

Date of interview:

1) Name of Interviewer... Tel No………………………
2) District..............................
3) Town/Village..
4) Name of respondent..
5) Gender: 1) Male 2)Female

6) What is your educational status? Tick as appropriate
   a) Primary c) Middle/JSS b) Secondary /SSS d) Tertiary
   e) Islamic education f) none g) other............

7) What type(s) of work (major) do you do in addition to farming? ....

8) How long have you been in the vegetable business? ....yrs
9) How many plots of vegetable land do you cultivate now? ....
10) Which vegetables do you grow on your farm?
    a) Tomato b) pepper c) okra d) cabbage
11) Which is your major?
    a) Tomato b) pepper c) okra d) cabbage
12) Which cultivar do you prefer? a) local b) exotic
13) Is postharvest loss a problem to you? a) Yes [ ] b) No [ ]
14) Please name the varieties you cultivate for your major crop.
    a) .... b)................................ c).......................
15) Source of planting materials? a) Family b) Friends c) MOFA
    d) Others......................................
16) What informs your choice
    a) Market preference b) ease of cultivation c) very portable
    d) less postharvest damage

HARVESTING AND HARVESTING OPERATIONS

17) How do you harvest your produce?
    a) Manual b) mechanical
18) If Manual, then specify. a) By knife cutting b) by hand twisting
    c) cutlass

19) What is the average maturity period of produce?
    a) 2-3 months b) 3-4months c) 4-5month d) if different please specify.............................

20) What time of the day do you harvest your fruits?
    a) Early in the morning b) after sunset (evening) c) any time of the day

21) At what stage of maturity of the fruit do you harvest?
a) When fully ripe b) when partially ripe c) when green and unripe
22) How do you check for the maturity of your produce before harvesting?
a) By hand feel b) By visual observation c) Uses an instrument to measure
23) Do you grade your produce immediately after harvesting? a) Yes ( ) b) No ( )
24) What quality indicators do you use for grading your produce?
a) colour b) size c) Weight d) shape e) Physical blemishes
25) What quantity of produce do/did you now harvest from your plot? ....
26) What quantity of produce do you sell on farm? a) all b) half c) quarter
27) Do you encounter insect pest on the vegetable? a) Yes ( ) b) No ( )

28) Can you name some of these pests
a)............................ b).............................. c)............................
29) What is the nature of damage they cause? Please State
....
....
30) Apart from the pest do your crops experience some disease problems?
a) Yes [ ] b) No [ ]

31) Do you know what causes these diseases?
....
....

32) Please describe the type, quantity and value of losses you incur during harvesting and the immediate post-harvest processing.

Stages of Handling	Nature of loss (see code below)	Quantity of produce harvested (weight)	Estimated losses (Quantity)	Value of loss (GH)
Harvesting Operations				
Gathering, transport, packing etc at farm				
Grading and sorting operations at farm				
Temporal processing (Drying, curing, etc)				
Transport to home, store, or market				

1=Weight loss 2=Presence of insects 3=Destruction by rodents/birds 4=rotting of fruits 5=Wilting and shrinking 6= Microbial or disease infections 7=Spillage 8=Boring by insects 9=others (specify)

33) What is the price of your vegetable per unit? GH¢................................

34) What do you think should be done to minimize these losses?
a)..
b)..

LOSSES AT STORAGE AND STORAGE PRACTICES

35) Do you store some of the produce after harvest? a) Yes ( ) b) No ( )

36) If yes, where do you store them before marketing? a) on farm b) at home

37) How long does your vegetable store?

Vegetable crops	Days	Weeks	Month	Years
Cabbage				
Pepper				
Tomato				
Okra				

38) Describe the types, quantity and value of losses you incur during storage at home or farm.

Location of Storage	Nature of loss (see code below)	Quantity of produce harvested (weight)	Estimated losses (Quantity)	Value of Loss (GH)
Storage on farm				
Storage at home				

1=Weight loss 2=Presence of insects 3=Destruction by rodents/birds 4=rotting of fruits
5=Wilting and shrinking 6= Microbial or disease infections 7=Spillage 8=Boring by insects
9=Others (specify)

39) How do you package your produce for storage? Specify...

40) What are the major storage problems of your produce?
a) ....
b) ....

41) Do you encounter some pests (insects, mites, and rodents) at storage?
a) Yes ( ) b) No ( )

42) If yes, how do you control these pests?
Specify..
....

43) What are some of the ways you adopt to improve the storage life of the vegetables?
   a) ....
   b) ....

MARKET LOSS ASSESSMENT

44) Please describe the losses you incur, including the quantity and value of losses during marketing of your produce

Stages of Handling	Nature of loss (see code below)	Quantity of produce harvested (weight)	Estimated losses (Quantity)	Value of loss (GH)
Loading and off-loading				
During transport to Market				
Storage at market				
During wholesale Points				
During retail points				

1=Weight loss 2=Presence of insects 3=Destruction by rodents/birds 4=Rotting of fruits
5=Wilting and shrinking 6= Microbial or disease infections 7=Spillage 8=Boring by insects
9=Others (specify)

PESTICIDE USE PATTERN

45) Do you use pesticides on your vegetables? What type of pesticides do you use?
   a) Insecticides b) Fungicides c) Herbicides d) Others....................

46) Why do you use pesticides on your vegetables?
   a) control pest and diseases b) store vegetables better c) early flowering d) others...

47) Please name the major chemicals you use.

Insecticides	Fungicides	Herbicides	Others

48) Which of the insecticide works better for you? Please specify..................................
49) What is the precise dosage that you apply?
Please specify...
50) How do you know the right quantity to use?
a) friends b) MoFA staffs c) pesticide dealers
d) other farmers
51) What time of day do you apply the chemicals?
a) early morning b) evening c) anytime of the day
52) At what stage of growth do you mostly apply the chemical in a season
a) after emergence b) throughout the growth c) prior to harvest
53) Do you think the chemicals you apply have an effect on the shelf life of the produce?
a) Yes [ ] b) No [ ]
54) What type of pesticide application equipment do you use
a) Knapsack b) Mist blower c) By hand d) Others

55) Who sprays the pesticides? a) self b) skilled labour (c) other (specify)............

56) Which of the protective clothing do you wear when spraying?

a) long sleeves b) trousers c) wellington boots d)nose mask

e) goggles f) all g) none of the above

57) How do you dispose of used pesticide containers? Please specify.............................

58) How long does it take to harvest the produce after spraying?

59) Do you apply chemicals after harvesting? Yes[ ] No[ ]

60) If yes what do you use and why.

....

61) Do you know the effects of these pesticides on our health? Yes[ ] No[ ]

62) If yes what are some of these effects?

....

....

APPENDIX II - QUESTIONNAIRE TO RETAIL TRADERS

Date of interview:

1. Name of Interviewer.. Tel no. ....
2. District..............................
3. Town/Village..
4. Name of respondent...
5. Gender: 1) Male 2)Female

6. What is your educational status? Tick as appropriate
   a) Primary c) Middle/JHS b) Secondary /SHS d) Tertiary
   e) Islamic education f) None g) other............

7. What type(s) of work do you do in addition to trading? ....
8. How long have you been in the vegetables business? ....yrs

9. What type of trader are you?

   a) assembler b) retailer c) wholesaler d) other (specify).....................

10. Please provide names for the most important communities where you get your produce.
    a)................................. b)............................... c).................................

11. Where do you obtain your vegetable produce from?
    a) on farm b) purchase from farmer c) purchase from wholesaler
    d) purchase from retailer

12. Please describe the types, quantity and value of losses you incur during purchasing and immediate post-purchase period.

Stages of Handling	Nature of loss (see code below)	Quantity of produce harvested (weight)	Estimated loss (Quantity)	Value of loss (GH)
Gathering, packaging, etc. at purchasing point				
Transport to home				
Grading and sorting Operations at home				

1=Weight loss 2=Presence of insects 3=Destruction by rodents/birds 4=Rotting of fruits 5=Wilting and shrinking 6= Microbial or disease infections 7=Spillage 8=Boring by insects 9=Others (specify)

13. Do you readily get transport to carry your produce to the market centre?
    a) Yes ( ) b) No ( )

14. How do you usually transport purchased produce to your point of sale?
    a) By own vehicle b) By appropriate rent/hired vehicle
    c) By any available passing commercial vehicle
    d) By any available head-loaded porter f) other..............................

15. Do you incur commodity losses from the point of purchase to the point of sale?
    a) Yes ( ) b) No ( )

16. How do you determine the price of your produce?
    a) Production cost b) Availability or scarcity of the product
    c) Price of other competitors d) Other (specify)....................................

17. What practice do you carry out when the vegetables reach the market?
    a) Sorting b) Washing c) other (specify)..............................

18. Please describe the losses you incur, including the quantity and value of losses during marketing of your processed produce.

Stages of Handling	Nature of loss (see code below)	Quantity of produce harvested (weight)	Estimated loss (Quantity)	Value of loss (GH)
Loading and off-loading				
During transport to Market				
During wholesale Points				
During retail points				

1=Weight loss 2=Presence of insects 3=Destruction by rodents/birds 4=Rotting of fruits 5=Wilting and shrinking 6= Microbial or disease infections 7=Spillage 8=Boring by insects 9=Others (specify)

19. Do you usually store produce? a) Yes ( ) b) No ( )

20. If yes, where do you store the produce?
a) At home b) at market or sale point

21. Please describe the types, quantity and value of losses you incur during storage at home or market.

Location of Storage	Nature of loss (see code below)	Quantity of produce harvested (weight)	Estimated losses (Quantity)	Value of Loss (GH¢)
Storage on farm				
Storage at market Or Sale point				

1=Weight loss 2=Presence of insects 3=Destruction by rodents/birds 4=Rotting of fruits 5=Wilting and shrinking 6= Microbial or disease infections 7=Spillage 8=Boring by insects 9=Others (specify)

22. Which storage facility do you keep your produce?
    a) Standard storage facility   b) Improved storage facility
    c) Common storeroom   d) Other (specify)..

23. How long do you store the produce?
Please (specify)..

24. How long does it take to sell your produce? Please Specify.................................

25. What do you think can be done to reduce the losses?
    ....
    ....

APPENDIX III - LIST OF PLATES

Plate 1: Interaction with a cabbage farmer at the Dzorwulu Railway.

Plate 2: Transportion of harvested tomatoes to the market

Plate 3: An interview with a garden egg trader at the Agbogbloshi market

Plate 4: A farmer spraying insecticides on his crop without protective clothing.

Plate 5: An empty insecticide container disposed off on the farm after use.