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ASSESSMENT OF PESTICIDE RESIDUE IN TOMATOES IN THE FANTEAKWA DISTRICTS IN THE EASTERN REGION OF GHANA

BY

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ASSESSMENT OF PESTICIDE RESIDUE IN TOMATOES IN THE FANTEAKWA DISTRICTS IN THE EASTERN REGION OF GHANA

A THESIS SUBMITTED TO THE SCHOOL OF RESEARCH AND GRADUATE STUDIES, KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY, KUMASI, IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE AWARD OF MASTERS OF SCIENCE (MSC. POSTHARVEST TECHNOLOGY) DEGREE.

BY

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DECLARATION

I hereby declare that except for references to other people's work which has been dully acknowledged, this work submitted to the school of Graduate Studies, Kwame Nkrumah University of Science and Technology (KNUST), Kumasi, is the result of my own original work and that this thesis has not been presented for any degree in this University or elsewhere.

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ABSTRACT

The Fanteakwa district of the Eastern Region of Ghana is one of the major tomato producing areas and so is faced with the challenges of pesticide usage. The objective of this study was, therefore, to find out the various pesticides used by tomato farmers, determine pesticide residue levels in tomato fruits and assess the effect of storage method on pesticide residue in tomato fruits produced from the Fanteakwa district. The study was conducted in two parts; a field survey and laboratory work. The survey was conducted using structured and semi-structured questionnaires administered to 120 farmers, 10 agrochemical sellers, 10 buyers and 20 consumers in the Fanteakwa district. Data collected was analysed using Statistix (version 9) Statistical Package and descriptive statistical tools. The result showed male dominance (85%) in tomato production with majority of the farmers (64%) having basic education. The result from the survey showed that thirty-eight (38) different pesticides with different trade names were used by farmers, of which 71.1% were organophosphates and pyrethroids, while 28.9% were fungicides and these chemicals were used in various cocktail forms. Contrary to laboratory results none of the farmers indicated their use of organochlorines in their routine pest control. Pesticide usage by farmers seemed to be highly influenced by agrochemical sellers in the farming communities. Majority of the consumers interviewed indicated that they did not have any complications after consuming fresh tomato fruits while only a few of the consumers indicated that they had diarrhoea. The laboratory analysis, involved the use of the Quick Easy Cheap Effective Rugged and safe (QuEChERS) Mini-Multi residue method, confirmed the presence of twenty-three (23) different pesticide residues comprising of organochlorines and pyrethriods pesticide. Compounds namely Beta_HCH, Gamma_HCH, Heptachlor, Aldrin, Allethrin, Gamma-Chord, α-Endosulfan, β-Endosulfan, Endosulfan Sulphate, Dieldrin, Endrin,

PP-DDT. PP-DDD, Bifenthrin, Fenpropathri, Methoxyclor, Lambda Cyhalothrin, Permethrin, Cyfluthrin, Cypermethrin Fenvalerate and Deltamethrin. Even though the survey results indicated that majority of the farmers did not allow for any pre-harvesting interval (safe harvest period), result from the laboratory analysis indicated that the mean concentrations of the 23 different pesticides residue found in the tomato samples were all below the MRL (WHO/FAO guidelines) of 0.05mg/kg and 0.02 mg/kg for those specific pesticides except for Delta-HCH which was found to be above the recommended maximum residue level of 0.05mg/kg for export for both fruits kept in ambient condition and in refrigerators. Significant differences ($P < 0.00$) were observed between tomato fruits kept under ambient conditions and those kept in the refrigerator for Delta-HCH ($t=24.68$, $p=0.00$), Lambda Cyhalothrin ($t=27.58$, $p=0.00$) and Permethrin ($t=36.06$, $p=0.00$. From the result of the study, storing tomato fruits for ten (10) days under ambient condition reduced pesticide reduced as compared to 10 days of refrigerated storage which could be due to photolytic decay.

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LIST OF ABBREVIATIONS

ADI Acceptable Daily Intake

ADRA Adventist Development and Relief Agency

CCPR Codex Alimetarius Commission on Pesticide Residue

DANIDA Danish International Development Agency

DFID Department for International Development

EC European Communities

EPA Environmental Protection Agency

FAO Food and Agricultural Organization

FRE Fully Registered for use in Ghana (valid for a maximum of three years)

GLC Gas Liquid Chromatography

GTZ German Technical Co-operation

HACCP Hazard Analysis of Critical Control Points

HCC Hazardous Chemical Committee

HPLC High Performance Liquid Chromatography

IDA Irrigation Development Authority

JICA Japan International Cooperation Agency

LD Lethal Dose

MiDA Millennium Development Authority

MOAP Market Oriented Agricultural Programme

MOFA Ministry of Food and Agriculture

MRL Maximum Residue Limits

OC Organochlorines

OP Organophosphates

OMAFRA Ontario Ministry of Food and Rural Affairs

PCL Provisional Clearance in Ghana (valid for a maximum of one year)

PDI Potential Daily Intake

QuEchERS Quick, Easy, Cheap, Effective, Rugged and Safe

TLC Thin Layer Chromatography

UN United Nations

UNIDO United Nations Industrial Development Organization

WHO World Health Organization

INTRODUCTION

Tomato, *Lycopersicon esculentum* Mill, is a member of the family *solanaceae*. The wild uncultivated forms of tomato are either biennials or perennial but under domestication the plant has become an annual. Tomato originated from the West Coast of South America and later taken to Europe across the pacific by the early Spanish explorers and Portuguese traders (Tweneboah, 1998).Tomato was introduced by the Europeans into West Africa around 1870 (Sinnadurai, 1992).The crop was later introduced into Ghana in the 16th and 17th centuries by the Portuguese and has since become the most popular vegetable crop (Norman, 1992: Nkansah *et al.*, 2003).

Tomato as an important vegetable crop ranks fourth among all vegetables. FAO estimates a total world production of 78.28 million tons from an area of 2.8 million hectares. In Ghana, tomato occupies an area of 50 thousand hectares with an average yield of 7.5 metric tons per hectare (MOFA, 2010). In Fanteakwa, a major growing district in the Eastern region of Ghana produced 16,342.16 metric tonnes from an area of 608.42 hectares (MOFA, 2007).

In recent years, technological breakthrough in agriculture has brought about rapid increase in the productivity level of crops through wider adoption of cost effective technologies, bringing more land areas under high yielding varieties, hybrid and increasing the cropping intensity with the help of irrigation facilities along with the use of chemical fertilizers and pesticides (Mukhopadhay, 2005). Trade liberalization without the establishment of effective pesticide management systems has allowed the introduction of sub-standard and unapproved pesticides into the country. More often than not, inadequately trained agrochemical sellers sell pesticides that are not recommended to innocent farmers to use on their crops. Ghana, is becoming a predominantly pesticide consuming country as pesticide are now being arranged and sold in the open on table tops in market places. Due to pesticide residue challenges, developed countries have established regular monitoring programmes that determine contamination levels (Reed *et al.*, 1987).

Pesticides belonging to the organophosphates, organochlorines, carbamates and relevantly small volume of pyrethriod compound are being used (Rahman *et al.,* 1995). Lacks of training, money, and illiteracy of farmers have been some of the reasons for applying inappropriate pesticides in crop (Lowell, 2008). Price (2008) also stated that pesticides are present in all compartments of agro- ecosystem, but perhaps the real risk to human is through the consumption of pesticide residues in food vegetables. Intensified use of pesticides can cause a serious public health hazard in the form of residue in food (Mansingh *et al.*, 1996). The World Health Organization(WHO) estimates there are 20,000 unintentional death and three million poisonings caused by pesticide misuse in the third world each year (Lowell, 2008). To ensure safety of consumers, countries have set minimum residue levels limits (MRL) based on the acceptable daily intakes (ADI) and the potential daily intakes (PDI) which should not be exceeded in various food items. The improper handling and the consumption of contaminated vegetables over long periods could result into chronic poisoning for which long term effect could lead to increased sensitivity to pesticides, and damage to the internal organs such as the liver (Arendse *et al.,* 1989). Of late, pesticide use has become indispensable in increasing vegetable crop production due to its rapid effect, ease of application and availability. This has generated new problems through the indiscriminate use of pesticides for which adequate attention has not been paid even though it has been recognized that the solution for these challenges is a requisite condition for fruit quality , food safety ,marketing and agricultural prosperity. For the farmers, the use of pesticide on their produce, have become as important as the adoption of new agricultural technology for improving their income from agriculture. A critical review of the poor performance of the agricultural sector, however, revealed several problems that militate against the growth of the sector: inadequate extension staff- farmer ratio, high rate of attrition of trained staff, weak research extension-farmer linkage, lack of reliable statistical data for decision making, weak agribusiness system, poor access to production areas and poor communication (MOFA, 2002).Also, there is no reliable data concerning the presence of pesticides, their use and residue levels in crop production in the Fanteakwa district in order to set priorities for action to remedy and prevent pesticide residue contamination and postharvest food safety.

The main objective of the study was therefore, to assess the pesticides levels in tomatoes from the Fanteakwa District.

The specific objectives of the study were to:

- determine the types of pesticide used by farmers;
- determine the pesticide residue levels in tomato fruits in the Fanteakwa District, and
- assess the effect of storage method on the pesticide residue levels in the tomatoes.

2.0 LITERATURE REVIEW

2.1 ORIGIN AND DISTRIBUTION OF TOMATOES

Tomato, *Lycopersicon esculentum* Mill, is a member of the family *solanaceae*. It originated from the West Coast of South America. It was later taken to Europe across the pacific by the early Spanish explorers and Portuguese traders (Tweneboah, 1998; Delahaut *et al.*, 1997). The major producing countries, in order of importance, are the United States of America, Italy, Russia, Spain, Egypt, Greece, Romania and Arab States..In Ghana, it is grown throughout the country but concentrated in the Greater Accra, Ashanti, Brong-Ahafo, Volta and Upper East Regions under both rain-fed and irrigated systems (MOFA, 2002). It contributes to the economic growth of the country and serves as source of foreign exchange (FAO, 2005). Some common varieties grown in Ghana are Navorongo, Power, Derma Roma, Asante, Wosowoso, Pectomech, F'adizebegye and Ada-cocoa (IDA/ JICA, 2004).

2.1.2 Botany of Tomato

Tomatoes are tender, warm-season, herbaceous perennials grown as annual. Plant may be semi- determinate, indeterminate or determinate in growth. Each shoot on a determinate plant ends with a cluster of flower, and consequently a cluster of fruits that tends to produce fruits all at once. Indeterminate varieties are sprawling in growth. The shoot tips continue to develop and cluster of flowers are produce in the leaf axils. The flowers are mainly self-fertilized and are primarily wind pollinated. Fruits may be red or purple, oblong, pear or round sharp depending on the variety. Leaves on the tomato plants are covered with fine hairs that emit a strong tomato smell or odour when crushed. The leaves are spirally arranged with lobed and divided blade. The calyxes are short and stay green when fruits ripen. The plant has a deep taproot system with several secondary side roots (Rice, 1993; Delahaut, *et al.*, 1997).

2.1.3 Importance of Tomato in the Economy

In 2003, a total of 4,368 metric tons of tomato were exported earning Ghana US$437,000 (FAO, 2005).Tomato occupies an area of 50 thousand hectares with an average yield of 7.5 metric tons per hectare (MOFA, 2010). In Fanteakwa, a major growing district in the Eastern region of Ghana produced 16,342.16 from an area of 608.42 hectares (MOFA, 2007). Appearance, colour, flavour, size, form and texture are probably the most important criteria used by consumers to evaluate the immediate quality in making choices for purchase and use of tomatoes (Schutz *et al.*, 1984; Aicha *et al*., 2006). The fruit may be eaten partially raw in sauces, salads soups, and stews or made into puree and pickles (Norman, 1992).

2.1.4 Nutritional and Health Benefits of Tomato

The tomato is widely used in several food preparations in Ghana because of its rich appreciable source of vitamins C, A riboflavin, protein, carotene and calcium in our diets (Bull, 1989; Wardlaw, 2003). Abushita *et al*. (1997) stated that the daily consumption of two tomato fruits provides the human with 2/3 of the needed vitamin C. Increasing evidence according to Dietary Guidelines (2005) highlighted the connection between eating vegetable and fruits and good health especially a decreased risk of wide range of serious diseases such as high blood pressure, heart diseases, diabetes, cancer, strokes and other chronic diseases. Tomato is considered as a fruit and vegetable and mostly eaten as vegetable in Ghana as part of cuisine and around the world. Ghana consumes approximately 800,000 metric tonnes of fresh and processed tomato per year and only 300,000-400,000MT of fresh tomatoes is produced locally (CSIR, 2011).Tomato contains lycopene which is a natural antioxidant. The nutritional value contain in 100 grams of tomato includes; 1gram, potassium-360mg, phosphorus-27mg, iron-0.6mg, calcium-11mg, vitamin C-23mg thiamine (vitamin B)-0.06 mg, vitamin A-1000 IU (http://www.dranny.com/food-nutrition/health-benefits-of-tomatoes/).

2.2 MAJOR PESTS AND DISEASES OF TOMATO IN GHANA

2.2.1 The White Fly (*Bamisatabaci*)

The white flies are small flies with piercing-sucking mouthparts. Adults are about 1mm in size and are white to yellow. Their bodies are covered with a powdery waxy material. At first glance they look like flies. Adults readily fly if disturbed. Nymphs (young ones) are usually pale yellow. They can be found on the back of the leaf. Early stages crawl about the leaf, whereas later stages assume a fixed position..

2.2.2 Aphids *(Aphidae)*

The aphids are most commonly seen in the rainy season. Plant with aphids will have: Ants on plants, Sooty mold on leaves, House flies on such plants all because sugary exudates from them. Aphids are small, soft-bodied, green, grey, or black insects with thin legs. Aphids may be winged or wingless and are usually slow moving. The insects cluster on the tips of the plant shoots. They have piercing and sucking mouth parts they reduce the vigour of the plants as they suck the plant food. Aphids are also carriers of viral diseases. The natural enemies are ladybird beetles that usually controls them effectively (Youdeowei, 2002)

2.2.3 Bollworm

It is a moth. The adult stage is not destructive. Eggs are laid on flower buds or leaves close to flowers newly hatched larvae begin feeding on the plant where eggs were laid on the tomato plant. Larvae make holes into flowers and developing fruits resulting to abortions. Caterpillar bores into fruits and eats the inner part. Fungi enter through the holes and cause fruit rot.

2.2.4 Nematodes

Plants are stunted, yellowing and general unthrifty in appearance. Infested plants may wilt or die in hot, dry weather. Belowground, the roots will have obvious galls or knot-like swellings. These swellings prevent movement of water and nutrients to the rest of the plant resulting in stunted plant growth. Plants affected by root-knot nematodes are more easily infected by soil-borne diseases caused by *Ralstonia solanacearum*(bacterial wilt), *Sclerotium rolfsii* (southern blight) *Fusarium*, *Pythium*, etc

2.2.5 Fusarium wilts (*F. oxysporum*)

It is a fungal disease the first symptoms seen are yellowing of the foliage. Lower leaves first and often begins on one side of the vine. Top of the vine wilts during the day and recovers at night. Wilting becomes intense as diseases progresses until the entire vine is permanently wilted. Vascular browning can be seen in infected stems and large leaf petioles. Vascular browning blocks movement of water to the leaves which leads to the wilting

2.2.6 Sclerotium Wilt

It is a fungal disease that infect and plants wilt suddenly. Unlike the wilting in *fusarium*, this type is permanent; there is no recovery in the evenings. Wilting plant parts are usually green except in older plants. The base of the stem (collar) reveals brown lesions covered with a white fungal mat and mustard-size sclerotia. Green wilting parts may resemble bacteria wilt. The difference will be the presence of the white mycelium and the fruiting bodies

2.2.7 Tomato Mosaic Virus

Symptoms on leaf Looks green and yellow mottling and fern-like foliage. On fruit it looks brown and spotting (centre) or gray blotches (right) on walls. Infected plant turns yellowing and become stunted with Leaf curling and; yellowing between veins and along margins

2.2.8 Bacterial Diseases

Bacterial diseases are favoured by humidity and temperatures. Some bacterial diseases which are commonly found on tomatoes are;

2.2.9 Bacterial Wilts (*Pseudomonas solanacearum*)

It is a soil disease which occurs together with nematodes. Symptoms vary considerably but it is usually accompanied by a sudden yellowing and plants wilting, first on the lower leaves during a hot day and then recovering at night. Few days later, a sudden and permanent wilt occurs. When the stem or roots are cut, a dark slim sap appears or a milky substance will ooze out of a clean surface of an infested plant portion immersed in clean water

2.2.10 Bacterial Spot (*Xanthomonas campestris*)

This bacterium is found in all parts of the world and spreads via seeds, insects, raindrops, infested plant remains and through solanaceae weeds. The bacteria enter the plant through the stomata and damages the fruits. Initial symptoms are tiny, circular, dark lesions on leaves, Lesions may coalesce causing blighted areas on leaves, immature fruit show brown; slightly sunken, scabby spots and lesions on stems are elliptical in shape.

2.3 POSTHARVEST QUALITY OF FRUITS AND VEGETABLES

According to the ISO (2006), Quality is defined as the totality of features and characteristics of a product that bears on its ability to satisfy the stated implied needs. Appearance, colour, freshness, taste, form, absence of pathogens, safety, flavour, aroma, and texture are probably the most important criteria used by consumers to evaluate the immediate quality in making choices for purchase and use of tomatoes (Zind, 1987; Schutz *et al.*, 1984;Aicha *et al.*, 2006).Quality makes a produce what it is: the combination of attribute or characteristics of a produce is what aids in determining its level of acceptability (Olympio *et. al.,* 2008). Grading scores as a means to describe the various quality of produce being offered and helps make pricing mechanism more precise and meaningful. The fruit may be eaten partially raw in sauces, salads soups, and stews or made into puree and pickles (Norman, 1992). In Ghana, the Food and Drugs Board (FDB), Ghana Standards Board (GSB), Environmental Protection Agency (EPA) and Plant Protection and Regulatory Services Directorate (PPRSD) of the Ministry of Food and Agriculture are the main regulatory bodies responsible for ensuring the safety of consumers by providing safety standards and regulations for food farmers and processors

2.3.1 Quality Attributes

UN (2007) indicates that, Quality attributes of fruits and Vegetables may be classified into three groups according to the occurrence of product characteristics when they are consumed or encountered.

2.3.1.1External quality

The external quality deals with quality attributes below:

- **Appearance (sight)** measures the following quality attributes: visual evaluation of size, gloss, colour, shape. Visual guides could also be used.
- **Feel (touch)** involves the manual evaluation of the firmness and texture. Mechanical texture analysis could also be used to further support the evaluation.
- **Defects** involve the visual evaluation of absence of defects or deterioration of colour. Mechanical methods such as ultrasound could be used.

2.3.1.2 Internal quality

The internal quality deals with quality attributes such as;

- **Odour is** mostly deals with qualitative and subjective evaluation by smelling and could be further evaluated by technical methods such as gas chromatography.
- **Taste (Oral tasting)** is used to evaluate sweetness, sourness, bitterness and saltiness. Technical quantification of taste compounds could be analysis using chromatography.
- **Texture** is used to evaluate tenderness, crispness, firmness, chewiness, crunchiness, fibrousness which is all measured by the application of force to the produce. Texture characteristics can be additionally evaluated through " mouth feel"

2.3.1.3 Hidden quality

The hidden quality deals with attributes such as;

- **Wholesomeness** of the produce. Wholesomeness is very difficult to measure objectively; it can be described as "freshness" "produce integrity"; it also has a sanitary component meaning how clean or hygienic the produce is.
- **Nutritive value.** The attribute of nutritive is measured by the content of nutrients such as carbohydrates, fats, essential vitamins, proteins, minerals and other substances that influence human well-being.
- **Food safety.** Food safety quality attributes can be measured via the examination of food items with regards to their pathogenic microbial load, chemical content contaminates or presence of physical foreign matter in the produce.

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2.4. HISTORY, DEFINITION AND CLASSIFICATION OF PESTICIDES

2.4. 1 Pesticide History

The history of pesticide dates back many centuries to before 1000 BC, when it was mentioned by Homer, but its real landmark in modern agriculture was during the spread of the Colorado beetle (*Leptinotar sadecemlineata*) that threatened potato crops across the United States of America (USA) in the second half of the nineteenth century (van Emden, 1989). According to Lah (2011), both the volume of pesticides used and amount of money spent on these pesticides illustrate our dependency on them. The Environmental Protection Agency (EPA) in the USA reported 4.9 billion pounds worth of pesticide usage in the USA in 2001 which is approximately 888 million pounds of active ingredients and 600 different chemical compounds inclusive. In the agricultural sector, 675 million pounds of pesticide active ingredient (76% of total active ingredient used) and 102 million pounds (11.5%) were used on lawns and gardens by homeowners and by government and the general industrial sector. Another 2.6 billion pounds used for disinfectants and 0.8 billion pounds used for preservation of wood. In the case of Worldwide, about 5.05 billion pounds of pesticide active ingredient were used in agriculture in 2001 (Lah, 2011).

2.4.2 Pesticide Definition

Pesticides, according to United State Department of Agriculture (USDA) 1998 and Arendse *et al.*, 1989, is a term broadly used to include synthetic organic chemicals used for destroying or preventing the activities of harmful insects, weeds, and diseases in the fields and mites that feed on crops and food crops. Pesticides can be classified differently. One of the ways in which pesticides can be classified is by the type of pest or diseases against which it is very effective: insect, fungi, bacteria, weeds, nematodes, mites, snails, slugs, and rodents (Arendse *et al.*, 1989).

2.4.3 Pesticide Classification

There are hundreds of pesticides. They have be classified by the World Health Organization (WHO) in different ways according to Arendse *et al.* (1989) which include;

I. By their chemical classes such as organophosphates, pyrethroids, organochlorines and carbamates etc.

II. By active ingredient required to kill half of the number of test animals (lethal dose for 50% =LD 50) to classify the degree of hazard in their toxicological classes such as class 1a -Extremely hazardous, demarcated in red; Class1b-Highly hazardous, demarcated in yellow; Class II -Moderately hazardous, demarcated in blue, Class III-Slightly hazardous demarcated green, while the remaining class is U supposed to be “Not likely to be Hazardous in normal use”.

III. By type of pest or disease against which it is effective such as insecticides, fungicides, herbicides, nematicides, acaricides, molluscicides, bactericides and rodenticides etc.

In Ghana, it is estimated that 87% of farmers use different classes’ of pesticides on vegetables of which 41% are pyrethroids and 37% are organophoshates. The rest are organochlorines and carbamates (Ntow, 2001). According to Danso *et al.* (2002), farmers mix cocktails of various pesticides to increase their potency and according to

Ngowi (2003), farmers lack agricultural extension service in order to make inform choices in the use of pesticides

2.4.4 Organochlorines (OC)

The properties of chemicals in this class such as DDT and many other organochlorines were not discovered till the late 1930's and are not unduly toxic to man, but they break down slowly, and some, like the soil insecticides aldrin, dieldrin, are very persistent in the environment (van Emden, 1989).

2.4.5 Organophosphates (OP)

This group of insecticides such as parathion ,diazinon, malathion, diamethorate and many more have been in existence since the 1940's with high acute mammalian toxicity or toxic to man but easily breaks down and are much less persistent than the organochlorines (van Emden, 1989).

2.4.6 Carbamates

Insecticides and Nematicides are carbamates (derivatives of carbonic acid) which were introduced in 1956 with the compound carbaryl. These groups of insecticides, nematicides such as aldicarb, benomyl, and carbofuran are more persistent than the organophosphates, highly toxic to man. Fungicides such as maneb and mencozeb under carbamates are not acutely toxic (van Emden, 1989).

2.4.7 Synthetic Pyrethroids

The pyrethroids are botanical. The real success in the use of these groups of insecticide came at Rothamsted Experimental Station in Britain in the early 1970's. Cypermethrin belongs to the pyrethroids. They are low in persistence, moderately toxic to man, and have very high acute toxicity to aquatic organisms (van Emden, 1989).

2.4.8 Ideal Pesticide

The ideal pesticides according to Kumar (1984), is the product that stays confined to the location of application through its active period; is toxic to particular pests but harmless to other organisms including human, is easy to use, ability to break down into harmless products in the environment within a reasonable time and must be cheap to produce. He further stated that pesticides are yet to achieve the totality of these properties.

2.4.9 Names of Pesticides

Kumar (1984) stated that pesticides may have three different names:

- Use of trade or proprietary names**:** under which the pesticides is marketed. Mostly, the trade names are commonly assigned to the pesticides.
- Use of active ingredient or chemical structure
- Use of a common name approved by a national or international organization, e.g. International Organization for Standardization. Sometimes codes are also used. These usually consist of a company initial plus serial number.

2.5 HAZARDS OF PESTICIDES

According to Fuglie (1998), the World health Organization (WHO) estimates 20,000 unintentional deaths and 3 million poisonings caused by pesticides misuse in the third world each year due to lack of training, lack of money or illiteracy, farmers applying inappropriate pesticides to crops without protective clothing and families consume treated seeds during lean periods. Sefa- Dedeh (2006) reported of challenges in the areas of maximum residue levels compliance and residue testing while consumers have high expectations for safe produce. In response to the above trends a list of pesticide active substances have been established for use on selected horticulture crops in Ghana (EPA, 2006).

There is currently overwhelming evidence resulting from the effect of some pesticides mixtures does pose potential danger to human health and other forms of life as well as unwanted side effects to the environment (Forget, 1993; Igbedioh, 1991; Jeyaratnam, 1981). According to the WHO (1999) no individuals or groups are completely protected against pesticide exposures and the potentially serious health effects, which usually affect people of the developing countries.

2.5.1Pesticide Formulations

Pesticides are available in various formulations which can either be in wet formulations; such as soluble concentration, demarcated by (SL, EC); suspension concentrates, demarcated by (SC); and ultra-low volume and ultra-low liquids, demarcated by (ULV and UL). Dry Formulations are wettable powder demarcated by (WP); water soluble powders, demarcated by (SP); dustable powders demarcated by (DP) or granule demarcated by (GR). The kind of formulation of a pesticide does determine the level of risks involved in its use and the safety measures required (Arendse *et al.*, 1989).

Pesticides are manufactured from either mineral substances such as oil or organic substances such as plant extracts. The toxic substances they contain are either found in nature (natural substances), or are invented and manufactured by man (artificial substances). Hugues and Philippe (1989) explained that proper application of pesticides offers a lot of advantages; however, the technical advantages cannot hide their disadvantages. Harold (2002), discussing the issue of pesticide regulation in West Africa, concluded that pesticides are poisoning many farmers, plantation workers and pesticide applicators in the region. In 1987 it was estimated that approximately 10,000 people died and about 400,000 suffered acute injuries from pesticide poisoning in developing countries (Hardin, 1972).

2.5.2 Health Effects

The general symptoms of pesticide poisoning are as follows according to Arendse, *et al.* (1989):

1. Mild Symptoms of pesticide poisoning include headaches, dizziness, tiredness, irritation of the eyes, skin, nose and throat, diarrhoea, excessive perspiration, and loss of appetite.
2. Severe Symptoms includes blurred vision, constricted pupils, stomach cramps, vomiting, difficulty with breathing profuse perspiration, tiredness, tremors and jerking of the muscles, and twitching.

3. Extremely Grave Symptoms includes convulsions, loss of consciousness, breathing stopping and no pulse.

2. 5.3 Pesticide Maximum Residue Limits

Consumers' exposure to pesticides due to the small quantities that are left on harvested crops raises challenges related to health issues. The quantities of pesticides left on food crops after harvest are known as pesticide residues. Maximum residue Limits (MRLs) are maximum amount of pesticide residue permissible in the animal or food crop commodity following an application of pesticides in accordance with Good Agricultural Practice (GAP). They are specific limits for pesticide residues in food commodities, established by national, regional or international authorities or organization (EPA, 2006; EC, 2008).

2.5.4 Principles of Good Plant Protection Practices

European Communities (2003) reported that the Principles of Good Plant Protection Practice (GPPP) provides the basis for the identification of optimal practice in the use of plant protection products. The principle provides practical standards for assessing individual practices with efficacy, human health, animal health and environmental safety being the principal endpoints. According to EPA (2006) Good Plant Protection Practice, permits the use of reduced rates of application and use of products in tank mixes, in certain specified circumstances, it does not permits use of plant protection products for purposes for which the product was not authorized. Good Plant Protection practice does not permit use at rates of applications higher or frequencies more often than provided for in the conditions of authorization and the conditions of use reflected on approved labels.

According to Aicha *et al.* (2006), hazard analysis critical control points (HACCP) system maintains food safety along the food supply chain from the farm to the consumer's table. It also consist of analyzing possible contamination hazards in order to identify the critical control points in the production line of the produce and therefore avoid the sources of possible contamination and ensuring food safety.

2.6 FOOD SAFETY ISSUES

The view to regulate pesticides residue to safer levels was originally initiated by the joint Food and Agriculture Organization and the world Health Organization (FAO/WHO) expert committee on food safety and they defined food safety as "all conditions necessary during production, processing, distribution, storage and during the preparation of food to ensure it is safe, wholesome, sound and fit for human consumption (Codex, 1995). To facilitate the implementation, the joint FAO/WHO food standards programmes, Codex Alimentarius Commission, comprising 120 member states, was established in 1964. The Codex Committee on Pesticide Residue (CCPR) is a subsidiary body on the Codex Alimentarius commission that advises on all issues relating to pesticide residues. The main objective was to come out with Maximum Residue Limits (MRLs) to protect consumers and foster international trade to avoid, for example, according to the Ghanaian Statesman (2006), a consignment of 2,000 metric tonnes of Cocoa beans from Ghana rejected by Japan as a result of excessive levels of pesticide residue in the beans. According to Ntow (1998), monitoring of pesticide residue on food is virtually nonexistent in Ghana and this is so because the analysis is too expensive for public authorities (Clark *et al.*, 1997).

Unsafe food from any part of the world causes devastating health, economic and political consequences. According to DeWaal and Nadine (2005), contaminated food contributes to 1.5 billion cases of diarrhoea in children each year, resulting in more than three million premature deaths. The World health Organization (WHO) (1999) revealed that, both developed and developing nations share those deaths and illnesses. According to Masud and Hassan (1992), pesticide residues were found in fruits been sold in markets which indicates the indiscriminate, wrongful and careless use of pesticides by farmers.

On-farm food safety related issues and quality assurance initiatives according to Ontario Ministry of Food and Rural Affairs (OMAFRA) (2004) are as a result of changing paradigm faced by the agricultural food system. Some decade ago, farmers' produce were freely marketed without strings attached. But of late, the reality is that farm produce production is shifted to the dictates of market requirements. Consumers now expect their food meets safety standards and increasingly, they want assurances of how their food is produced in addition to assurances of produce quality and safety (OMAFRA, 2004).

Whitehead and Field (2002) have classified food hazard into three categories: physical, chemical and biological. Physical hazards (e.g. Stones in grains. Bone pieces and others like metal chips in meat products) are most likely to be understood by people but far more complex and less understood are the nature of the impact or consequences of chemical which if misapplied or not recommended can lead to the contamination of crop lands, water sources and more importantly result in the accumulation of pesticides residues in crops especially crops that are eaten in the raw state as well as biological hazards on human health related issues because of the nature of complexities. For instance the level of pesticide residue, which is capable of causing harm to an individual, can only be determined through laboratory analysis.

Sefa-Dedeh (2006) reported of the high expectation of consumers for food safety but the challenge has been on maximum residue compliance and residue testing. The horticultural industry of Ghana has developed the manpower needs in producing and maintaining quality management standards to assure safe produce deliverance. Sefa-Dedeh (2006) stated the horticultural sector's strategies for establishing quality assurance and food safety as part of the operational management plan of the various actors. The GhanaGAP concept is been initiated in establishing a national quality management assurance management system. The initiative is a gradual mainstreaming of good agricultural practices that seeks to rising standards in the horticultural sector and to also facilitate produce quality, safety and traceability. This can help prevent farmers from mixing cocktails of various pesticides with the aim to increase their potency (Danso *et al.*, 2002).

2.6.1 Analytical Techniques Used for Pesticide Residue Analysis

There are several techniques that can be used for pesticide residue analysis in vegetable and fruit crops (Richter *et al.*, 2001) including the QuEChERS (Quick, Easy, Cheap, Effective, Rugged, and Safe) method, thin layer chromatography (TLC), gas liquid chromatography (GLC), and high performance liquid chromatography (HPLC).

2.6.1.1 Application of QuEChERS Method

The analysis of pesticide residues using the Quick Easy Cheap Effective Rugged and Safe (**QuEChERS)** method includes these basic steps:

I. Simple preparation and extraction. The sample is uniformly homogenized and soaked with acetonitrile for a shake extraction. Salts, acids and or buffers may be added to enhance extraction efficiency and protect sensitivity analytes,

II. Dispersive solid phase extraction cleanup (dSPE)- in this step $MgSO_4$and solid phase extraction (SPE) absorbents are used to remove excess water and unwanted contaminants (matrix) from the extracted samples,

III. Simple analysis by gas chromatography mass spectrometry (GC/MS)techniques-A solvent exchange or pH adjustment might be necessary

2.6.1.2 Application of Thin Layer Chromatography

Patil and Shingare (1993) used thin layer chromatographic detection method for the determination of organophosphorus insecticides containing the nitrophenyl group. The Organophorus compounds were reduced using stannous chloride in HCl-water (1:1) to amino derivatives, which are further diazotized and coupled with 1-naphthylamne to give intense pink-orange spots. Pasha and Vijayashankar (1993) gave details of a thin layer chromatographic method for determination of deltamethrin, permethrin, cypermethrin, pyrethroids and several others. After spotting and elution the plate was exposed to bromine vapours and then sprayed with 0.1% o-toluidine solution. Intense blue spots appeared after exposing under sunlight for five minutes.

2.6.1.3 Application of high Performance Liquid Chromatography

The gas chromatography has been the major analytical method used in the determination of pesticide residue in crop produce due to its high separation ability and the presence of GC-amenable pesticides in several samples. Some compounds cannot be determined straight forward by GC directly due to poor volatility, high level of polarity, and thermal instability (Fillion *et al*., 1995). Fungicides, carbamates and herbicides in fruits were determined by high- performance liquid chromatography with UV detection. Samples were extracted in 10% methanol in methylene chloride and cleaned up the sample content using Extrelut ® (Merck, Germany) column (Ohlin, 1986).

2.6.1.4 Application of Gas Chromatography

Wan *et al.* (1994) described a very simple and an expensive multi-pesticide determination method of organochlorines and pyrethroid pesticides (alpha BHC, gamma-BHC (Lindane), heptachlor, aldrin, alpha endosulfan, beta endosulfan, bifenthrin, cypermethrin, DDE DDT and deltamethrin in vegetable. The pesticide products found in vegetables were extracted with ethanol and partitioned into toluene. Amini-column packed with 0.5g of Florisil was used to further clean-up prior to gas chromatographic determination. Pesticide recoveries from fortified samples were 65-97% at the 0.1µg/g level and 87-114% at the 0.5µg/g level. Reagents needed for the analysis of a sample is 100ml ethanol, 6ml toluene and 0.5g Florisil.

2.6.2 Institutions and Agencies Involved in food Safety and Regulation in Ghana

Sefa-Dedeh (2009) listed the key actors in Ghana's food safety sectors to include: 1) Ghana government being responsible for setting regulatory standard, certification, policies, enabling environment, 2) Ghana government in partnership with development partners, 3) Private Sector which involves the farmers, market intervention both local and export sectors, processors, distributors and consumers, 4) Public- private initiatives such as the National Codex Committee and the Horticultural Task Force.

Food safety involves several interrelated activities which cut across multi disciplines that need collaborated efforts from the government ministries, agencies, organizations and ministries while parliament enacts regulation to provide main corpus of food law. A comprehensive food system needs a dynamic interdependency of a number of factors such as the farmers, marketers, the private sector, consumers, governmental bodies, researchers and educational organizations (FAO, 2002). A frame work system is needed to harmonize the various actors' roles to enhance a collaborative interdependency, cohesiveness and effective communication between the major actors. In Ghana, the Ghana Standard Board and the Food and Drugs Board are the major regulatory institutions mandate in ensuring the safety and quality standards of all consumables besides other governmental institutions.

2.6.3. Status of Food Safety and Legislation

Safa-Dedeh (2009) reported of the formation of institutions with specific mandates derived from various enacted legislative instrument such as the Legislation on Food and Drugs: Food and Drugs (Amendment) Act, 1996 (Act 523) Article 5. Section 7 of PNDCL 305B amended by renumbering and insertion of the following new subsection (2) "Foods shall be stored and conveyed in such a manner as to preserve its composition, quality and purity and to minimize the dissipation of its nutritive properties from climatic and other deteriorating conditions", Legislation on the Environment: Environmental Protection Agency Act, 1994 (Act 490), Pesticides Management and Export Control Act, 1996 (Act 528), Standards Decree, 1967 (NLCD 199), superseded by the Standards Decree, 1973 (NRCD 173), Ghana Standards (Certification Marks) Rules, 1970 (LI662), Ghana Standards (Certification Marks) (Amendment) Rules, 1970 (LI 664), Standards (Amendment) Decree, 1979 (AFRCD 44), Ghana Standards Board (Food, Drugs and other goods) general Labelling Rules, 1992 (LI 154).

2.6.3.1 Ghana Standards Authority (GSA)

The Ghana Standards Authority formerly called Ghana Standards Board (GSB) was established according to Sefa- Dedeh (2009), by NRCD 1973 and vested with the object of ensuring high quality in goods produced in Ghana, whether for local or for export; Development of standards, provision of certification services, provision of inspection services, promote standardization in industry and commerce; promote industrial efficiency and development Promote standards in public and industrial welfare, health and safety under its Article 2, NRCD 173. FAO (2000) reported recent international agreements emphasised the need for food safety measures to be based on risk analysis following principles and procedures elaborated by relevant international organization.

2.6.3.2 Food and Drugs Board (FDB)

The Food and Drugs Board was established by the Food and Drugs Law PNDCL 305B which was enacted to control the manufacture, importation, distribution, use and advertisement of foods, drugs, cosmetics, chemical substances and medical devices. The Law contains provisions on prohibitions against the manufacture and sale of unwholesome, poisonous and adulterated foods. The Law was amended in 1996 by the Food and Drugs (Amendment) Act, 1996 Act 523.

Article 5 Section 7 of PNDCL 305B amended by renumbering and insertion of the following; new subsection to include clauses such as food shall be stored and conveyed in such a manner as to preserve its composition, quality and purity and to minimize the dissipation of its nutritive properties from climatic and other deteriorating conditions". The Food and Drugs Board has two main sectors which are mainly; the inspectorate division for drugs and the inspectorate division for food. The board has the mandate to define food safety policy activities, coordination with other institutions involved with food safety, food premises inspection, post market surveillance, food safety and quality management, and research on food standards and legislation. Occasionally, educational awareness creation programmes are carried out to educate the general public on food safety to aid consumers in making inform decisions.

2.6.3.3 Plant protection and Regulatory Services Directorate

The Plant Protection and Regulatory Services Directorate (PPRSD) of the Ministry of Food and Agriculture was established through the PPRSD Bills Supporting Activities: Prevention and control of pests and diseases of plants Act 307 (1965), Pesticide control and management Act528 (1996) and the Seed inspection and certification Decree, NRCD 100 (1972). The Pesticides Management Control Act, 1996 (Act 528) Section 17 of this Act states: states that no person shall import, export, manufacture, distribute, advertise or sell any pesticides except in accordance with a license issued under the Act. It is important to note that no regulations have been enacted pursuant to Act 528 to address pesticide residues in foods and the protection of the consumer or the certification of agricultural produce in respect of the level of chemical residues. Gerken and Suglo (2002), suggested government interventions must work to achieve its objective of increasing agricultural productivity to enhance food security by adopting an integrated crop production approaches that will avoid the indiscriminate use of pesticides to meet specified maximum pesticide residue levels.

2.6.3.4 Environmental Protection Agency

The Environmental Protection Agency (EPA) was established by the Environment Protection Agency Act, 1994 (Act 490). The mandate of the EPA includes the issuance of environmental permits and pollution abatement notice for controlling the volume, types, constituents and effects of waste discharges, emissions, deposits or other sources of pollutants and of substances which are hazardous or potentially dangerous to the quality of the environment or any segment of the environment.

The EPA is expected to form the Hazardous Chemical Committee (HCC) under section 10 of The EPA Act with a mandate of: Monitoring the use of hazardous chemicals by collecting information on the importation, manufacture, exportation, distribution, sale and disposal of such chemicals; Advise the Board and the Executive Director on the regulation and management of hazardous chemicals. Pesticide residues in food have been of prominent concern all over due to health implication. Pesticides are further regulated under the Pesticides Management Control Act, 1996 (Act 528) (Sefa –Dedeh , 2009). Other related partner organization in the promotion of food safety include according to Sefa- Dedeh (2009), the Department for International Development

(DFID): that lays much emphases on Street foods- safety hazards; control and elimination, UNIDO duly promoting conformity with market requirements. Strengthen standards bodies to harmonize standards, Upgrade PPRSD seed inspection and certification laboratory, The World Bank-led Multi-donor Initiative in the Horticulture Export Initiative with focus on Addressing food safety, quality management, pesticides, cold chain infrastructure, USAID- Trade and investment Program for the Competitive Export Economy (TIPCEE) with focus on two major components in (export development and enabling environment). The Development of supply chain system for export fruits, including GlobalGap certification; policy and regulatory issues, legal framework for pesticide importation, sale, use and disposal, GTZ-Market Oriented Agriculture Program(MOAP) with its focus on poverty alleviation through increased competitiveness of agricultural farmers. Strengthened agricultural associations, assist in GlobalGap certification. Millennium Development Authority (MiDA) which aims to raise farmer incomes through private sector led agribusiness development. Assist PPRSD to enable compliance with international plant protection standards, and DANIDA-Trade Sector Support Program which focuses on the development of national standards strategy, streamlining institutional mandates, laboratory improvements and standards for local market.

METHODOLOGY

3.1 FIELD SURVEY

3.1.1 Profile of Study Area

The Fanteakwa District is located within the central part of the Eastern Region of Ghana. It shares boundaries with Afram Plains District in the north, to the northwest by Kwahu South District, south by the East Akim and Atiwa District and to the east by Yilo and Manya Krobo district. It lies within longitudes 0°32.5' West and 0°10'East and latitude 6°15' North and 6°10' South. It is bounded to the north by the Afram Plains and Volta Lake, to the North West by Kwahu South District, south by the East Akyem and Manya Krobo District and to the east by the Yilo Krobo.

The District has about 148 communities. With a total land area of 1150 sq km, Fanteakwa District occupies 7.68% of total land area within the Eastern Region (18,310 sq km) and constitutes 0.48% of the total land area in Ghana. The district had a total population of 86,154 during the 2000 National Population Census with males constituting 42,625 and 43,529 females. Currently the district's population is projected to be 131,586 and is projected to increase to 146,737 in 2013 with a growth rate of 3.7%.

The district lies within the wet-semi equatorial region with means and annual rainfall between 1500mm to about 2000mm.The district also experience two raining seasons; one in June and the other in October with slight deviation. During the rainy season there is brief interruption of the sun by thick cloud cover which increases the temperature of the atmosphere. Averagely, the district experiences an annual temperature of 24 degrees

Celsius. Due to the agrarian economy nature of the district, the agriculture sector employs about 55% of the district labour force in which small scale farming and shifting cultivation is the main traditional land management system. Crops grown include tomatoes, plantain, cassava, onions, cabbages, carrots and garden eggs, and maize among others.

3.1.2 Sampling Area and Sampling Size

Major tomatoes producing areas in the Fanteakwa District in the Eastern Region was used for the study. Areas selected included Begoro, Obuoho, Kankamah and Oneku communities. A total of 140 respondents consisting of 100 tomato farmers, 10 agrochemical sellers, 10 buyers and 20 consumers of tomato were randomly selected from the communities.

3.1.3 Sampling Technique

Purposive sampling technique which is a non-probability sampling method was used. This technique enables the researcher to choose persons that are relevant to the research and are easily available to the researcher.

3.1.4 Questionnaire Design

The study focused on ascertaining the major pesticides used by the tomato farmers in the Fanteakwa District. Semi-structured questionnaires were used to obtain the relevant information from the respondents in the district. For the farmers some of the parameters considered included their bio-data, farming experience, cultivation practices, pesticide usage, pests and diseases of tomato. For the agrochemical sellers, bio-data, types of pesticides sold to farmers, registration status, special trainings in pesticide handling attended, types of pesticides bought by farmers and level of knowledge in pesticide handling were studied. For buyers of tomato bio-data, quality of tomatoes bought, final selling points, kind of assistance given to farmer, awareness of pesticides used by farmers, quality of tomato fruits bought, point of purchase from farmers and perception of pesticide usage were also looked at. Consumer's questionnaire covered bio-data, fruit quality preferences and complications suffered after eating tomato fruits.

3.1.5 Questionnaire Administration

The questionnaires were pre-tested on a small sample of respondents in three tomato producing communities namely; Suminakese, Hweehwee and Kwahu Tafo in the Kwahu East District of the Eastern Region for content validity as specified by Rogers (1995). Personal interviews and administration of semi-structured questionnaires was used in obtaining information from the farmers, buyers, agrochemical sellers and consumers.

3.1.6 Data Sources

Primary data was obtained from the survey conducted and secondary data sources from District Hospital in the Fanteakwa District, ADRA Ghana and Ministry of Food and Agriculture.

3.1.7 Data Analysis

Data collected was analysed using two sample t-test at 5% significant level using Statistix (version 9) statistical software.

3.2 LABORATORY EXPERIMENT

3.2.1 Experimental Site

Laboratory work was carried out at the Ghana Standard Authority laboratory in Accra using the Quick Easy Cheap Effective Rugged and Safe (QuEChERS) Mini- Multi residue method which is for the analysis of pesticide residue in low-fat products.

3.2.2 Source of Tomato Fruits

Fresh and healthy tomato fruits were obtained from 20 tomato farms at Begoro, Obuoho, Kankamah and Oneku catchment areas in the Fanteakwa District.

3.2.3 Sample Preparation

Fruits were neatly packaged into ventilated paper cartons and sent to the Ghana Standards Authority laboratory in Accra for analyses. The composite sample was divided into two 10kg packs. One sample was stored in the refrigerator at (5±4°C) and the other kept under ambient temperature of 24°C.

3.2.4 Extraction of Multi Residues Pesticide from Tomato Fruits

The Quick, Easy, Cheap, Effective, Rugged and Safe (QuEChERS) mini multi-residue method for the analysis of pesticide residues was used. In this method homogeneous and representative sample of the tomato fruit was cut coarsely into 3×3cm with a knife and blended using a warring blender (Foss Homogeniser, model. 2096) for the two samples (refrigerated and ambient). 10g of the tomato homogenate was placed in a 50ml centrifuge tube with screw cap. 10ml of acetonitrile was added and shaken vigorously with the hand for 1min. A mixture of 4g of Magnesium sulphate anhydrous, 1g of Sodium chloride, 1g of Trisodium citrate dehydrate and 0.5g disodium hydrogen citrate sesquuihydrate were added and shook vigorously for another 1 min. The sample was centrifuged at 3000rpm for 5min.

After centrifugation, a 6mL aliquot of the extract was transferred into a polypropylene (PP) single use centrifugation tube containing 150mg primary-secondary amine (PSA) and 900mg magnesium sulphate. The tube was shaken vigorously for 30 seconds and centrifuge at 3000 rpm for 5 min. Four millilitres aliquot of the extract was again transferred into a round bottom flask and acidified with 40ml of 5% formic acid in acetonitrile and concentrated to dryness using a rotary evaporator. The cleaned and acidified extract was reconstituted in ethyl acetate and transferred into auto sampler vials. The determination of analyte was done with a gas chromatography technique using Varian CP-3800. The procedure was done for the initial fruits harvested and repeated for 2, 4, 6, 8 and 10 days after storage.

3.2.5 Experimental Design

A Complete Randomized Design (CRD) was used. Three replicates of the tomato samples were used. The treatments consisted of tomato fruits stored in refrigerators (5±4^{o}C) and fruits kept in ambient conditions (24^{o}C).

3.2.6 Parameters Studied

Multi-pesticides chemical constituents such as synthetic pyrethroids, organochlorines and organophosphates were measured.

3.2.6.1 Multi-pesticides chemical constituents

Multi-pesticides chemical constituents such as synthetic pyrethroids, carbamates (fungicides) and organochlorines and organophosphates were looked at.

3.2.6.2 Estimated average daily intake of pesticide residue

Estimated acceptable daily intake was calculated based on the formula:

$$EADI = MPCx\ Consumption\ rate$$

Where

EADI - Estimated Average Daily Intake of Pesticide Residue

MPC – Mean pesticide concentration

Per capita food consumption rate for tomato in Ghana (Darko, 2009) = 0.037Kg day^{-1}

3.2.6.3 Hazard Index for Pesticide

The hazard index for the pesticides detected was calculated using the formula:

$$Hazard\ Index\ (HI) = \frac{EADI}{ADI}$$

Where

ADI - Acceptable Daily Intake

EADI - Estimated Average Daily Intake

3.2.7Data Analysis

Data collected was analysed using two sample t-test at 5% significant level using Statistix (version 9) statistical software.

4.0 RESULTS

4.1 INTRODUCTION

This chapter deals with the results and findings obtained from the survey and laboratory analysis carried out in the study area (Fanteakwa District). The results cover responses from farmers, buyers, agro chemical sellers and consumers. It also analyses the pesticides reduce levels in tomatoes sampled from farms in the district.

4.2. TOMATO FARMERS

4.2.1. Bio-Data of Farmers

Table 4.1 shows the bio-data of tomato farmers in the Fanteakwa District. Majority of the farmers were male (85%) while 15% were females. Most of the farmers (37%) were aged between 40-49 years, 35% were aged between 30-39 years, 13% of farmers were within 50-59 years, 11% between 20-29 years and 4% were aged 60 years and above.

On educational background, 64% of the farmers were educated up to the Junior High (JSS) or hold Middle School Leavers Certificate as their highest qualification, 8% were educated up to the primary level while only 4% had secondary level education. However, 11% of the farmers had no formal education. None of the farmers interviewed had tertiary education qualification.

Table 4.1 Bio-data of Farmers

		Frequency	Percentage
Sex	Male	85	85
	Female	15	15
Total		100	100
Age	20-29 years	11	11.0
	30-39 years	35	35.0
	40-49 years	37	37.0
	50-59 years	13	13.0
	60 years and above	4	4.0
Total		100	100.0
Education	No formal education	11	11.0
	Primary	8	8.0
	JSS/MSLC	64	64.0
	SSS	4	4.0
	Tertiary	-	-
Total		100	100.0

Source: Field survey, 2012.

4.2.2 Farming Experience of Farmers

Table 4.2: Farming experience of the farmers

	Frequency	Percentage
1-5 years	17	17.0
6-10 years	33	33.0
11-15 years	20	20.0
16-20 years	14	14.0
20 years and above	16	16.0
Total	100	100.0

Source: Field survey, 2012.

Table 4.2 indicate the farming experience of the tomato farmers interviewed. From the study, majority (33%) of the respondents had been in the farming business between 6-10 years, 20% of the respondent fell between 11-15years, 17% of the farmers had between 1-5years, and 16% of the respondent had experiences above 20years while 14% of the tomato farmers had experiences between 16-20 years.

4.2.3 Farm Sizes of Farmers

Table 4.3: Farm size of farmers

Acreage	Frequency	Percentage
Less than 1 acre (>0.4ha)	12	12.0
1-5 acres (0.4-2ha)	78	78.0
6-10 acres (2-4ha)	8	8.0
Above 10 acres (<4ha)	2	2.0
Total	100	100.0

Source: Field survey, 2012.

Table 4.3 indicates farm sizes of respondents. From the survey conducted, 78% of the respondents interviewed indicated that the farm sizes ranged between 1-5acres, 12% had farm sizes less than 1acre, 8% of the farmers had farm sizes between respondent that acres. However, 2% of the tomato farmers had farm lands greater than 10 acres.

4.2.4 Varieties of Tomato Grown by Farmers

Table 4.4 shows the varieties of tomatoes grown by farmers in the Fanteakwa District. The findings indicates that 38.48% of the respondent cultivated Power, 29.8% cultivated Pectomech, 10.6% cultivated Ada-Cocoa, 6.6% cultivated Derma and Roma, 3.3%

cultivated Navrongo, 2.6% cultivated Wosowosom while 1.3% cultivated Asante. However, a small percentage (0.7%) of the farmers cultivated Fa'dzebegye tomato variety.

Table 4.4 Tomato Varieties Grown in Fanteakwa District

Varieties	Frequency	Percentage
Navrongo	5	3.3
Power	58	38.4
Derma	10	6.6
Roma	10	6.6
Asante	2	1.3
Wosowosom	4	2.6
Pectomech	45	29.8
Fa'dzebegye	1	0.7
Ada-Cocoa	16	10.6
Total		100

Source: Field survey, 2012.

4.2.5 Pest Management Practices during Crop Production

The types of insect pests identified and controlled by farmers are indicated in Table 4.5. from the interviews conducted, 34.2% of the respondent mentioned fruit borer as their major insect pest, 21.1% indicated leaf worm, 17.7% of respondents sprayed against white flies, 16.9% sprayed against aphids, 4.6% treated crops against nematodes/ root knot while 1.7% of the respondents sprayed against termite attacks. However, 3.8% of the respondent protected their crops against other insect pests such as grasshopper, ants and mites.

Table 4.5: Type of insect pest farmers control on their tomato

Pests controlled	Frequency	Percentage
Leaf worm	50	21.1
Fruit borer	81	34.2
Whitefly	42	17.7
Termites	4	1.7
Aphids	40	16.9
Nematodes/ root knot	11	4.6
Others (grasshopper, ants, mites)	9	3.8
Total		100.0

Source: Field survey, 2012.

4.2.6 Disease Management Practices during Crop Production

Table 4.6: Tomato diseases controlled by farmers

Disease controlled	Frequency	Percentage
Wilt	69	25.3
Leaf spot	64	23.4
Leaf curl	64	23.4
Fruit rot	48	17.6
Blossom-end rot	27	9.9
Blight	1	0.4
Total		100.0

Source: Field survey, 2012.

Table 4.6 shows tomato disease controlled by farmers in the Fanteakwa District. Farmers interviewed sprayed against wilt disease (25.3%), 23.4% of them sprayed against leaf spot disease and leaf curl disease, 17.6% of the farmers interviewed sprayed against fruit rot disease while 9.9% of farmers sprayed to control blossom end rot disease. However, 0.4% of the farmers interviewed sprayed to control blight disease.

4.2.7 Sources of Pesticide Used by Famers

Table 4.7: Sources of pesticides to farmers

Sources of pesticides	Frequency	Percentage
From friends	2	2.0
In the markets on table tops	23	23.0
From vehicles that come on market days	9	9.0
From agro-chemical shops	66	66.0
Total	100	100.0

Source: Field survey, 2012.

Table 4.7 shows the where the farmers obtained their pesticides from. From the survey, most of them (66%) of the farmers bought their pesticide from Agro-chemical shops, 23% of the respondent bought their pesticides from peddlers who sold on table tops in the markets, 9% of the respondents from roaming vehicles that peddle pesticides in various communities on market days while 2% of the farmers bought from friends within the study area.

4.2.8 Insecticides and Fungicides Used for Tomato Production

Table 4.8 indicates the different kinds of pesticides used at different stages in the production of tomato. From the study it was revealed that at the nursery stage of production 13 different kinds of insecticides and 10 fungicides were used in pest and disease management. At the growth stages, 13 different insecticides and 9 fungicides were used. For the flowering stages, 11 different insecticides and 9 fungicides were used. During fruiting of the tomato plant, 9 different insecticides and 10 fungicides were used. Finally at harvesting of the fruits, 5 different insecticides and 9 fungicides were also used.

Table 4.8: Pesticides used during the tomato production

Stages of production	Pesticide	Trade name
Nursery	Insecticide	Power, Anti-atta, Thiodan, Wireko, Dursban, Furadan, Attack, Confidor, Kombat, Cyidin, Nordox, Cydem, Golan
	Fungicide	Topsin, Diathane, Rodomil, Top cop, Sulpher 80, Kocide, Nordox, Funguran-OH, Champion, Kocides
Growth	Insecticide	Considal, Lamda , Polythrinegolan, K-optimal, Thiodan Anti-atta, Wireko, Dursban, Attack, Confidor, Kilsect, Celex, Akate-suro
	Fungicide	Topsin, Champion, Dithane, KocideRodomil, Topcop, Sulpher80, Defender, Funguran-OH, Folpan
Flowering	Insecticide	Power, Anti-atta, Thiodan, Deltaphose, Dursban, Attack, Confidor, Kombat, Nordox, Golan, Polythrine
	Fungicide	Topsin, Diathane, Rodomil, Top cop, Sulpher 80, Kocide, Funguran-OH, Champion, Kocides,
Fruiting	Insecticide	Power, Anti-Atta,Polythrine, Attack, Confidor, Master, Dursban, M-Fos, Termex. Tiatan
	Fungicide	Topsin, Diathane, Rodomil, Topcop, Sulpher 80, Kocide, Funguran-OH, Champion, Kocides, Nordox
Harvesting	Insecticide	Power, Wireko, Attack, Master, Polythrine, M-Fos, Bossmate
	Fungicide	Topsin, Diathane, Rodomil, Top Cop, Sulpher 80, Funguran-OH, Champion, Kocides, Defender

Source: Field survey, 2012.

4.2.9 Choice of Pesticide Used by Farmers

Table 4.9: Reasons for choice of pesticide used by farmers

Reasons	Frequency	Percentage
Price is moderate	4	1.8
Effective control	90	41.3
Easily available	26	11.9
Improve fruit colour	49	22.5
Keep fruit firm	49	22.5
Total		100.0

Source: Field survey, 2012.

Reasons assigned by farmers for their choice of pesticide for controlling pests and disease in tomato are presented in Table 4.9. From the interview conducted, 41.3% of the farmers select their pesticide based on its effectiveness in pests and disease control, 22.5% select pesticides for their tomato cultivation based on the pesticide's ability in keeping the tomato fruits firm and improving the tomato fruit colour, 11.9% based their choice on its availability while 1.8% of the respondents select pesticide based on price affordability.

4.2.10 How Pesticides Are Measured By Farmers

Tables 4.10 shows the containers used in measuring pesticides by the farmers. Twenty-two per cent (22%) of farmers interviewed use tea spoon in measuring pesticides, (20%) of use pesticide lid in measuring, 19% use small empty tomato tin as a measure for insecticide, 12% of farmers measured fungicides using empty milk tin while 10% of the respondent used table spoon. However, only 17% of the farmers followed the instructions given on the labels in the application of the pesticides.

Table 4.10: Measuring Containers used to Dispense Pesticide by Farmers

Measuring Containers	Quantity	Frequency	Percentage
Tea Spoon	5ml (insecticide)	22	22
Table Spoon	10ml (insecticide)	10	10
Small Tomato Tin	40-50ml (insecticide)	19	19
Pesticide Lid	5ml-30ml (insecticide)	20	20
Calibrated Measure	5- 50ml	17	17
Milk Tin	200g (fungicide)	12	12
Total		100	100

Source: Field survey, 2012.

4.2.11 Protective Clothing Used during Pesticide Application

Table 4.11: Use of protective clothing during pesticide application

Protective clothing	Frequency	Percentage
Nose mask	59	17.3
Goggles or spectacles	36	10.6
Short sleeves	10	2.9
Long sleeves	71	20.8
Shorts	3	0.9
Field Boots	90	26.4
Trousers	72	21.1
Total		100.0

Source: Field survey, 2012.

The type of protective clothing used during spraying activities is shown in Table 4.11. From the survey, 26.4% of farmers wear field boots, 21.1% wear trousers, 20.8% uses long sleeve shirts, 17.3% uses nose mask, 10.6% uses goggles whiles 2.9% wear short sleeve shirts. However, 0.9% of farmers interview worn shorts when spraying.

Table 4.12: Reasons why some farmers do not use some protective clothing

Response	Frequency	Percentage
Am not used to it / not comfortable	12	20.0
It is too costly	12	20.0
I don't have it	20	33.3
I don't see its importance / not necessary	8	13.3
They are not good protector	2	3.3
Not available on the market	4	6.7
They expose some body parts	2	3.3
Total	60	100.0

Source: Field survey, 2012.

Table 4.12 shows the reason assigned by farmers who do not use any protective clothing during pesticide application. It was revealed from the survey that 33.3% of the respondents did not have the protective clothing to wear, 20% of the farmers were not comfortable wearing the protective clothing while others said they were too costly to buy, 13.3% indicated that protective clothing were not necessary, 6.7% said they were not available on the markets whereas 3.3% said the clothing were not good protectors and that parts of the body are exposed during spraying.

4.2.12 Application of Pesticides during Harvesting

Table 4.13: Application of pesticide during harvest period by farmers

Responses	Frequency	Percentage
Yes	65	76.5
No	20	23.5
Total	85	100.0

Source: Field survey, 2012.

When the farmers were asked whether they sprayed their crops during harvesting, 76.5% of the respondents indicated that they spray the tomato crop during the harvesting period while 23.5% of the farmers do not spray their crops during the harvesting period (Table 4.13). Farmers assigned various reasons as to why they apply pesticides during the harvesting period. Some indicated that the application enhanced fruit firmness, gave better fruit protection, improved fruit colour and ripening to meet market days. For the few farmers who did not apply pesticides during harvesting, they indicated that the pesticides were not safe for consumption, takes time to break down and it was against the directive of the Ministry of Food and Agriculture (MoFA).

4.2.13 Pre-Harvest Interval Used by Farmers

Table 4.14 shows the pre-harvest interval for tomato fruit after the application of pesticide. From the study, 43.8% of the farmers waited between 4-6 days after application before harvesting is done, 16.9% harvest within 2-3 days after spraying and 4.5% of the farmers harvest a week or more after application of pesticides. However, 34.8% of the farmers harvest the same day after pesticide application.

Table 4.14: Pre-harvest interval for tomatoes after pesticide application

Interval	Frequency	Percentage
0 day (same day)	31	34.8
2-3 days	15	16.9
4-6 days	39	43.8
More than 7 days	4	4.5
Total	89	100.0

Source: Field survey, 2012.

4.2.14 Pesticides Combination (Cocktails) Used by Farmers

Table 4.15: Use of pesticides combination (Cocktail) in tomato production

Responses	Frequency	Percentage
Yes	84	84.0
No	16	16.0
Total	100	100.0

Source: Field survey, 2012.

Table 4.15 indicates responses of farmers in using pesticides combinations or cocktail in controlling pests and diseases in their tomato crops. From the study, 84% of the farmers indicated that they mix different pesticides when spraying their tomato crop in the field while 16% of them reported that they do not mix pesticides when spraying their tomato crop.

Table 4.16: Number of pesticide used in cocktail preparation

Number of Pesticide	Frequency	Percentage
One	6	7.2
Two	17	20.2
Three	46	54.8
Four	15	17.9
Total	84	100.0

Source: Field survey, 2012.

The number of pesticides used in mixes or cocktails is presented in Table 4.16. Majority of the farmers (54.8%) interviewed indicated that they mixed three different pesticide types when controlling pests and diseases on their tomato crops, 20.2% indicated they mixed two pesticides types whereas 17.9% mixes four pesticides types when controlling pests and diseases on their tomato crop. However, only 7.2% of the farmers interviewed used one pesticide in fighting pests and disease problems on their crop.

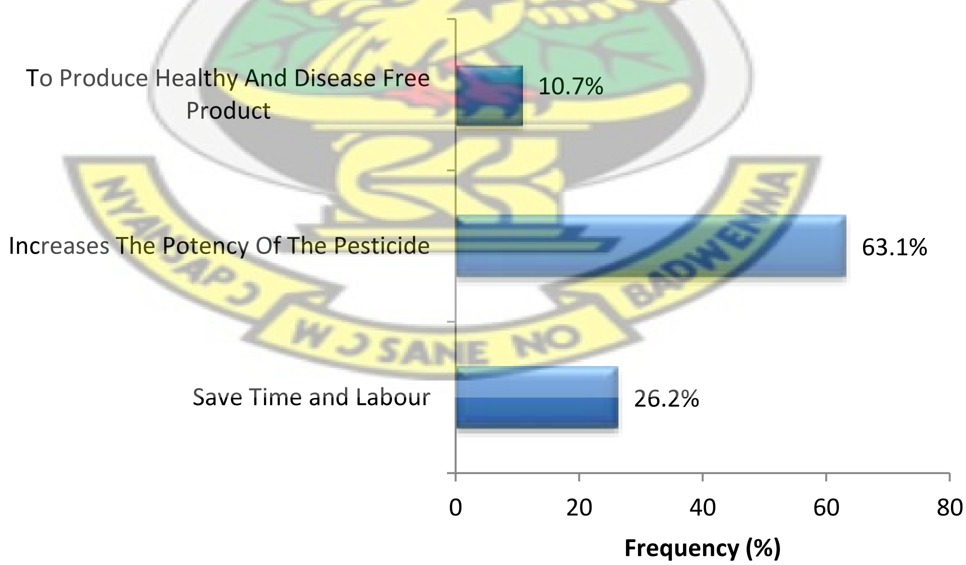

Figure 4.1: Reasons why farmers mixed different pesticides (cocktail)

Figure 4.1 above shows the reasons why farmers mixed different pesticides in the field. It was obvious that out of the 84% (Table 4.15) who mixed different pesticides, most of them (63.1%) did so to control pests on the field, while 26.2% said the mixing, additionally, saved time and labour. Only 10.7% of them said it produced healthy and disease free products.

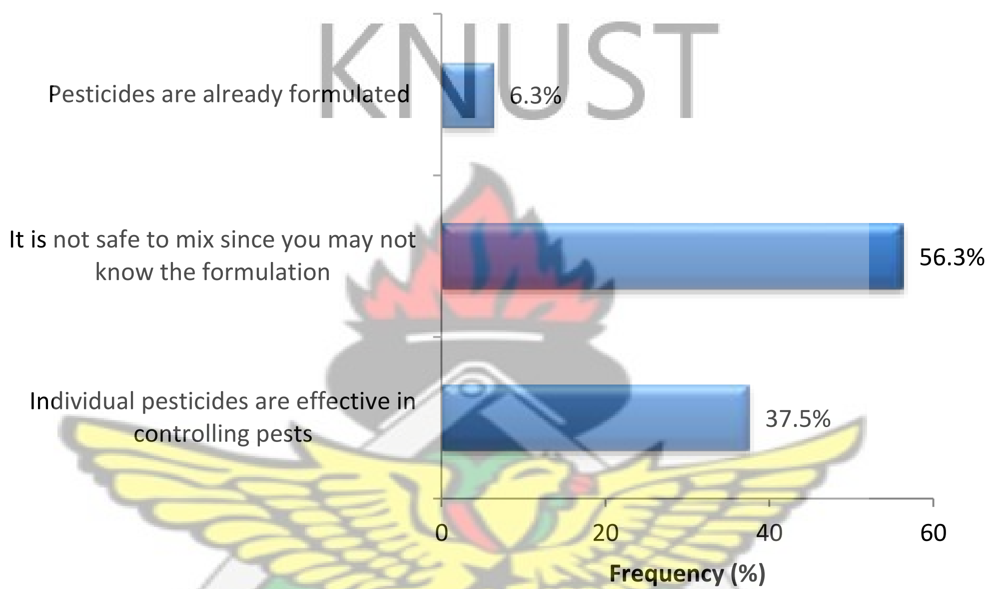

Figure 4.2: Reasons why farmers do not mix pesticides (cocktail)

Out of the 16% of farmers who did not mix pesticides (Table 4.15), majority of them (56.3%) indicated that it was not safe to mix the pesticides since they may not know the chemical constituents. 37.5% indicated that the pesticides were effective in controlling pests, therefore, there was no need to mix them, while 6.3% of them said that they did not mix them because the pesticides have already been formulated for effective pest control (Figure 4.2).

4.2.15 Self-Reported Pesticide Poisoning Symptoms by Farmers

Table 4.17: Self-reported pesticide poisoning symptoms by farmers

Signs of poisoning	Frequency	Percentage
General weakness	4	3.3
Skin problems (burning and rashes)	77	64.2
Sneezing	18	15
Dizziness and Headache	21	17.5
Total		100.0

Source: Field survey, 2012.

Table 4.17 indicates the self-reported signs of pesticide poisoning by farmers. Most of the farmers (64.2%) reported skin problems such as burning and rashes, 17.5% of farmers reported neurological system disturbances such as dizziness and headache whiles 15% reported of severe sneezing. However, 3.3% of tomato farmers indicated that they experienced general weakness.

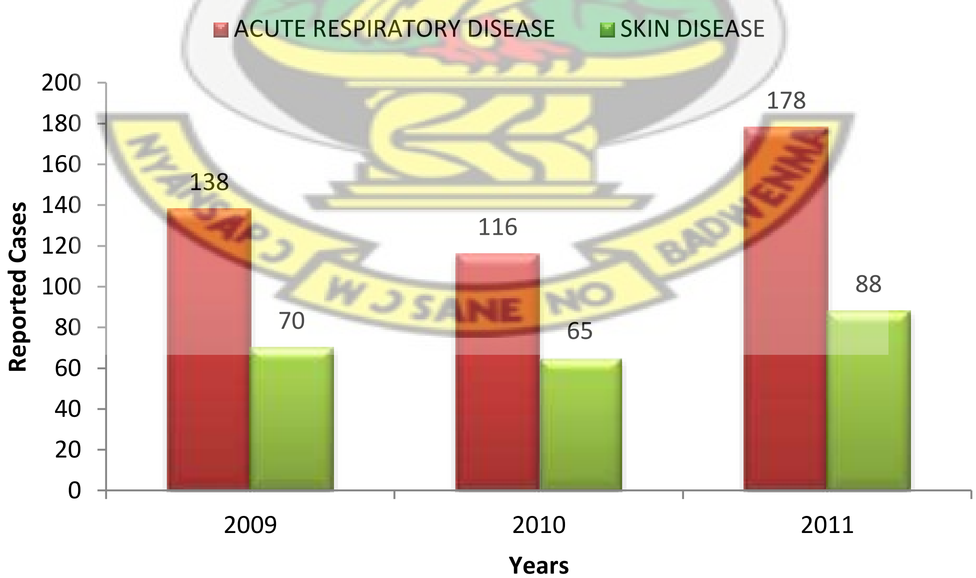

Figure 4.3: Reported health cases at the Fanteakwa Government Hospital (2009-2011)

Reported health cases of acute respiratory disease and skin disease at the Fanteakwa Government Hospital is presented in Figure 4.3. Data on males aged between 30-49 years between 2009 to 2011, showed that acute respiratory disease was the most common illness reported in the district than skin diseases over the years. The highest incidences of acute respiratory disease and skin disease were recorded in 2011.

4. 2.16 Sale of Tomato by Farmers

Figure 4.4 shows how marketing of tomato is done by the farmers. Half of the farmers interviewed indicated that they sold their tomatoes on the farm (50%), 37% of the farmers sold their tomatoes in the markets, 21% of the farmers sold their produce to wholesalers whereas 15% of the farmers dealt directly with the retailers.

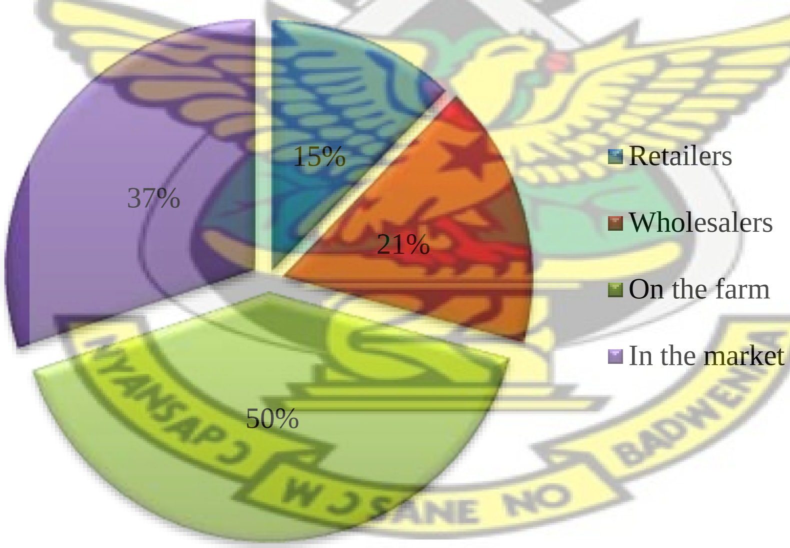

Figure 4.4: Marketing of tomato by farmers

4.2.17 Complaints of Buyers with Regards to the Tomato they bought from Farmers

When the farmers were asked whether they receive complaints from the buyers, 36.1% of the respondents had received complaints from buyers while 63.9% of the farmers said they had not received any complaints (Figure 4.5).

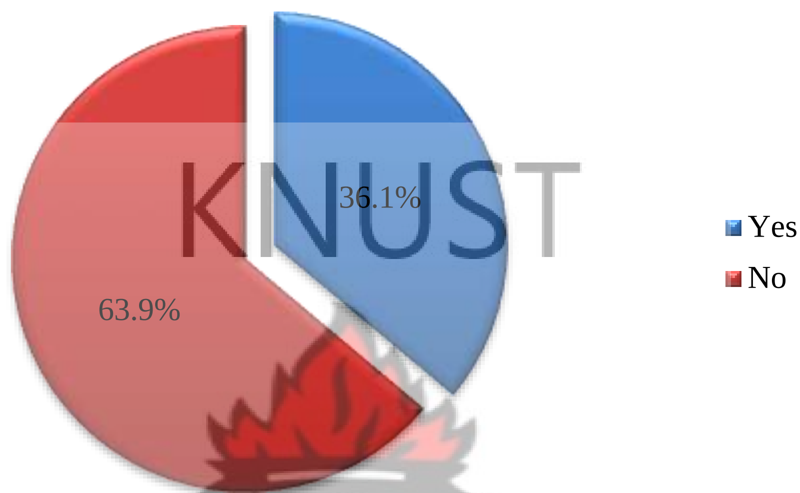

Figure 4.5: Complaint pertaining to the sales of tomato by farmers

Table 4.18: Complaints received by farmers

Complaints	Frequency	Percentage
Rotting and cracking of fruits	10	47.6
Softness of fruits	5	23.8
Insects damage	1	4.8
Poor packaging of tomatoes	3	14.3
Fruits are not appealing to consumers	1	4.8
The variety is not customers choice	1	4.8
Total	21	100.0

Source: Field survey, 2012.

Some of the complaints received from the buyers are presented in Tale 4.18. Most of the respondents indicated the buyers complained of rotting and cracking of the tomato fruits

(47.6%), softening of fruits (23.8%), poor packaging of fruits (14.3%), insect damage (4.8%), fruits not appealing to consumers (4.8%) and the fact that the tomatoes varieties cultivated are not customers' choice (4.8%).

4.2.18 Consumption of Tomato by Farmers

Table 4.19: Farmers preference for tomato fruits from their farm

Response	Frequency	Percentage
Yes	100	100.0
No	0	0.0
Total	100	100.0

Source: Field survey, 2012.

Finally, when the farmers interviewed were asked whether they consume tomato produce from their farms, all the respondents indicated that, they consume tomato fruits from the farm (Table 4.19).

4.3 AGRO CHEMICAL SELLERS

4.3.1 Registration Status of Agro-Chemical Shops

Table 4.20: Registration status of agrochemical shops

Status	Frequency	Percentage
Not Registered	6	60.0
Registered with Registrar Generals Office	3	30.0
Registered with EPA Office	1	10.0
Total	10	100.0

Source: Field survey, 2012.

Table 4.20 shows the registration status of agro-chemical shops in the district surveyed. From the result, more than half (60%) of the respondents interviewed indicated that the shops were not registered, 30% said the chemical shops were registered with the Registrar Generals Office where as 10% had registered with the Environmental Protection Agency (EPA).

4.3.2 Pesticides Wrongly Sold to Farmers Based on Mode of Action

Table 4.21: Pesticides wrongly sold to farmers based on mode of action

1).Contact Insecticides Wrongly Sold as Systemic insecticides	**Active ingredient**
Lambda Super 2.5EC	Lambda
K-Optima	Lambda + Acetamiprid
Polythrine	Cypermethrin
Dursban	Chloropyrifos
Sunperifios	Chloropyrifos
Termex	Chloropyrifos
2).Contact Fungicide Wrongly Sold as insecticides	**Active ingredient**
Champion	Copric hydroxide
3).Contact Fungicides Wrongly Sold as Systemic fungicides	**Active ingredient**
Nordex	Cuproud oxide
Folpan	Folpet
Top Cop	Sulphur

Source: Field survey, 2012.

Table 4.21 depicts pesticides wrongly sold to farmers by chemical sellers, based on their mode of action. From the results, Lambda Super 2.5EC, K- Optima, Polythrine , Durban, Sunperifios and Termex wrongly sold as systemic insecticides were in fact contact insecticides. Champion wrongly sold as contact insecticides was infarct a contact fungicides. Nordex, Folpan and Top Cop were wrongly sold as systemic fungicides but are contact fungicides.

4.3.3 Farmers' Ability to Explain Problem clearly to Agrochemical Sellers

As shown in the Figure 4.6, most of the agrochemical sellers interviewed (70%) indicated that farmers were not able to express themselves or clearly explain their problems to them. Nonetheless, 30% of the sellers interviewed said farmers were able to explain themselves through probing, the use of samples of diseased or infected plant parts and they (agrochemical sellers) used their working experience to help the farmers.

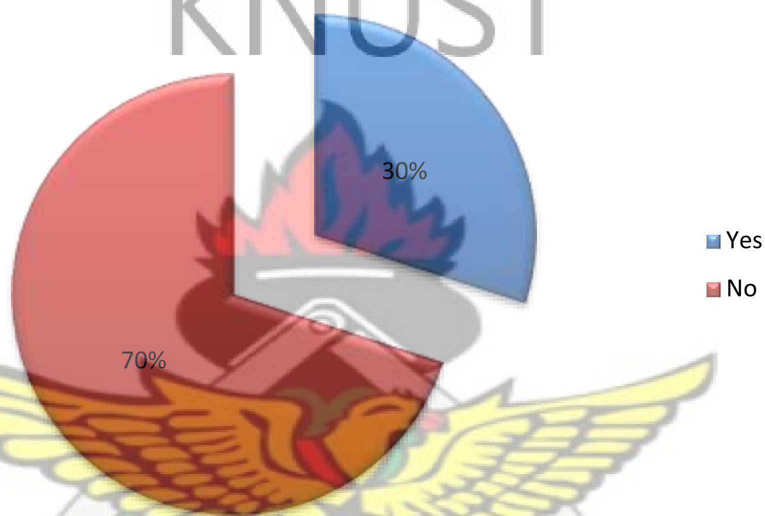

Figure 4.6: Farmers ability to explain their problem clearly to agrochemical sellers

4.3.5 Strategies Used to Assist Farmers on Pesticide Used

Table 4.22: Strategies used by agro-chemical sellers to assist farmers on pesticide use

	Frequency	Percentage
Consult with MoFA staff	5	50.0
Basic training and reading basic research materials	1	10.0
Reading label instruction on chemical usage	2	20.0
Attending training workshops	2	20.0
Total	10	100.0

Source: Field survey, 2012.

Table 4.22 shows strategies used by agro-chemical sellers to assist farmers on pesticide use. From the survey, 50% of the shop attendants consult with the Ministry of Food Agriculture (MoFA) staff, 20% read pesticide label instruction to assist farmers, and 20% alluded to knowledge acquired through trainings workshops attended and 10% of the attendant uses basic training and research materials in assisting farmers in their pesticide use.

4.3.6 Sources of Pesticide used by Farmers

When the agrochemical dealers were asked if farmers always buy their pesticides from them (Figure 4.7), 60% of the chemical sellers responded that the farmers usually bought their pesticides from them whilst 40% said, the farmers obtained their pesticides from other sources other than the approved sources.

Figure 4.7: Sources of pesticide used by farmers

4.3.7 Other Pesticide Outlets Used by Farmers

Table 4.23: Pesticide outlets (unapproved) used by farmers when they do not buy from agrochemical sellers

Outlets	Frequency	Percentage
Chemical peddlers (moving vehicles)	4	66.6
Local market (selling on the floor and table tops)	1	16.7
Other farmers (friends and family)	1	16.7
Total	6	100.0

Source: Field survey, 2012.

Pesticides outlets used by farmers are presented in Table 4.23. The survey showed that more than half of the respondents interviewed (66.6%) indicated that farmers buy from chemical peddlers who are untrained and sells from moving vehicles, 16.7 % of the respondents also mentioned that farmers buy from the local market where prices are cheaper whereas 16.7% indicated that farmers do buy pesticides from other farmers on table tops.

4.3.8 Problems Farmers Face from Buying from Unapproved Sources

Table 4.24: Problems farmers face from buying from unapproved sources based on complaints received by agrochemical sellers from farmers

	Frequency	Percentage
Buying adulterated chemicals	1	10.0
Buying expired pesticides	4	40.0
Inadequate information on pesticides	1	10.0
Wrong chemicals	3	30.0
Unlabelled chemicals that cannot be trace	1	10.0
Total	10	100.0

Source: Field survey, 2012.

Problems faced by farmers from buying from unapproved sources are presented in Table4.24. Forty per cent (40%) of the shop attendants indicated that expired pesticides may be sold to the farmers, 30% of the attendants were of the view that wrong chemicals may be sold to the farmers, 10% of the shop attendants anticipated farmers buying adulterated chemical, 10% also indicated that farmers may buy pesticides that lack adequate information on the chemicals and 10% were of the opinion that unlabelled chemicals sold to the farmers may be difficult to trace.

4.3.9 The Role of Regulatory Agencies in the Use of Pesticide

Table 4.25: Role of regulatory agencies in the use of pesticides

	Frequency	Percentage
Government policies on the use and sale of pesticides	1	10.0
Regular monitoring of chemical sellers by appropriate agency	5	50.0
Trainings of chemical sellers	4	40.0
Total	10	100.0

Source: Field survey, 2012.

Table 4.25 shows some suggestions from Agro chemical sellers to bring sanity in the sales of pesticides to farmers. From the survey, 50% of the respondents suggested regular monitoring of pesticide sellers by appropriate agencies such as EPA, MoFA and Ghana Standards Authority, 40% of the respondents also suggested training of chemical sellers and 10 % of the respondents interviewed indicated that government should formulate policies that would control the activities of agro-input dealers and pesticide use by farmers.

4.4 BUYERS OF TOMATOES

4.4.1 Number of Years Buyers have been in Tomato Business

From the study, the respondents had been in the tomato trade between 10 to 35 years. The average number of years the buyers had been in business was 19years.

4.4.2 Point of Tomato Purchase

Figure 4.8 shows the point of sale of tomato from the study area. From the respondents interviewed, 60% of the respondents bought their tomato fruits from the farm gate because it was cheaper, well packaged and bulk purchases could be made their ten percent (10%) of them bought their tomato fruits from the market centres because farmers sent their produce there to sale. However, 30% of the respondents bought their tomato fruits either from the farm gate because of scarcity of the fruits at the market centres, or from the market centres when the fruits are in season and so the farmers bring the tomatoes to the markets themselves.

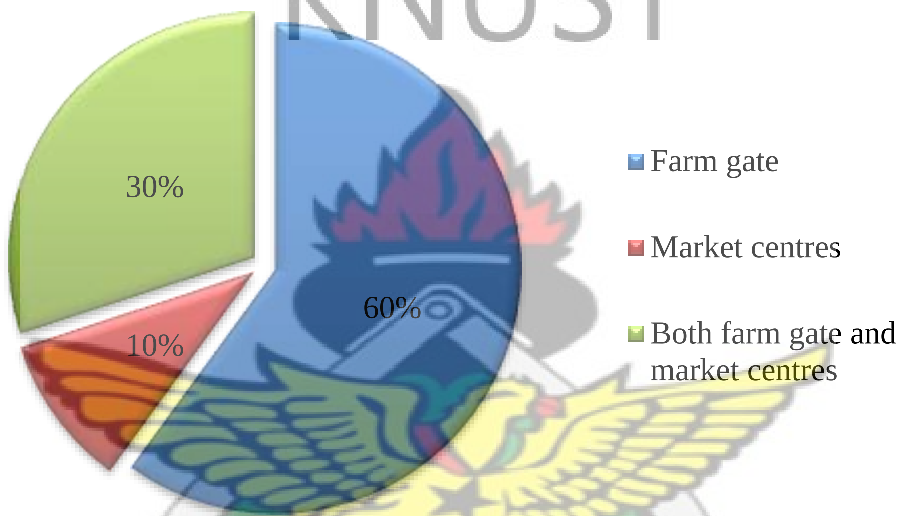

Figure 4.8: Point of tomato sales

4.4.3 Support Given by Buyers to Farmers

The survey result revealed that 70% of the buyers gave support to the tomato farmers either in the form of cash or inputs in the form of seeds and fertilizers while 30% of the buyers did not give any form of assistance as shown in the Figure 4.9.

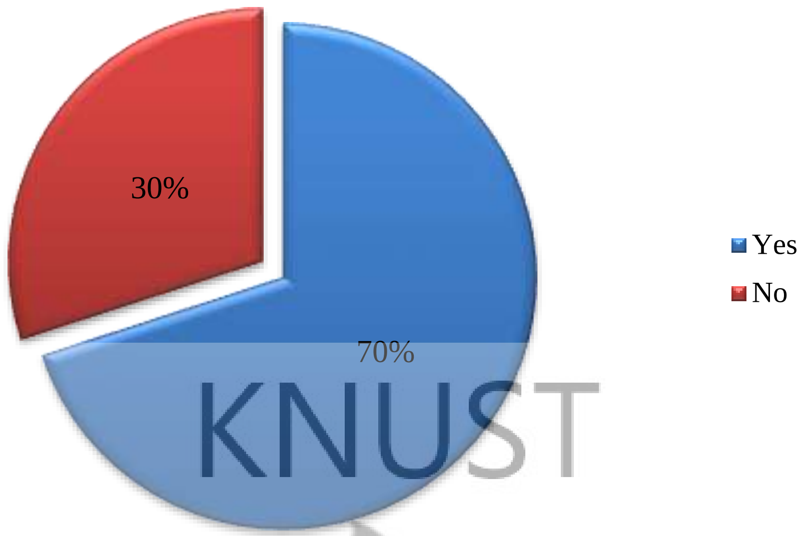

Figure 4.9: Support given to tomato farmers

4.4.4 Problem Associated with the Purchase of Tomatoes from Farmers

Table 4.26: Problems Associated with tomato purchased

Problems associated	Frequency	Percentage
Fruits rots and cracks	6	60.0
Abuse of pesticides by farmers with traces seen on fruits	1	10.0
Unstable price and vehicle breakdown	2	20.0
Poor packaging of tomato by farmers	1	10.0
Total	10	100.0

Source: Field survey, 2012.

Problems associated with the purchase of tomato are presented in Table 4.26. Majority of the respondents (60%) interviewed indicated that fruit rots and cracks attributed to the tomato variety were the major problems faced with the purchase of tomato by the buyers, 10% of buyers complained of pesticide abuse and traces on tomato fruit bought, 20% of respondents reported that unstable prices and vehicle breakdown and delays also impede the trade and 10% of the buyers indicated that poor packaging of tomato fruits farmers also form part of the problem.

4.4.6 How Buyers See the Use of Pesticides by Farmers

Table 4.27: Buyer's impression about pesticides used by farmers

Response	Frequency	Percentage
Help in plant growth, fruit setting and good fruits appearance	4	44.4
Pesticides helps to keep the fruits store longer	3	33.3
Using banned chemicals on the fruits	1	11.1
Excessive use chemicals reduce the storage period of the fruit	2	22.2
Total	10	100.0

Source: Field survey, 2012.

The impressions of buyers about the use of pesticides by farmers are presented in Table 4.27. The study revealed that 44.4% of the buyers perceive the use of pesticides as good and that it helps the plant to grow well, enhance fruit setting and improved fruit appearance; 33.3% of the buyers indicated that the use of pesticides helps the fruits stay longer and 22.2%% of the buyers perceived excessive use of pesticides to contribute to reduced storage period of the tomato fruits. However, 11.1% of the respondents interviewed were worried about the use of banned pesticides on the fruits.

4.4.7 Quality of Tomatoes Bought from Farmers

Figure 4.10 indicates buyer's satisfaction with the quality of tomato fruit bought from the farmers. From the study, 55.6% of the buyers were satisfied with the quality of tomato fruits they bought from the farmers while 44.4% were dissatisfied with the quality of fruits bought from the farmers.

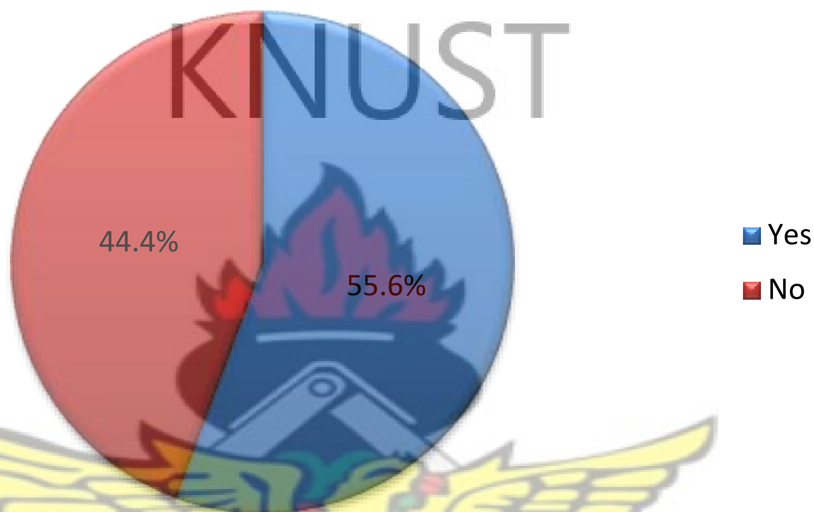

Figure 4.10: Quality of tomatoes bought from farmers

The buyers who were satisfied with fruits bought indicated that the bright fruit colour and appearance attracted customers to buy and also quantities of tomato fruits supplied help them stay in the business. However, for buyers who were not satisfied with the tomato fruits bought, indicated that the fruits were over ripe fruits, had short shelf life, rot in storage and had pesticide stains on the fruits which reduced the quality of the fruits.

4.4.8 Comments Received by Sellers Regarding the Quality of Tomatoes Sold

Table 4.28: Comments regarding the quality of tomatoes sold

Response	Frequency	Percentage
Fruit softness, cracking and rotting	5	55.5
Pesticide stains on fruits	1	11.1
Bitterness of fruit when eaten fresh	3	33.3
Worm in tomato fruits	1	11.1
Total	10	100.1

Source: Field survey, 2012.

Table 4.28 shows comments received from customers regarding the tomato fruit sold. From the study, 55.5% of the respondents indicated that customers commented on fruit softness, cracking and rotting, 33.3% of the respondents indicated that customers commented on the bitter taste of the fruits when eaten fresh, 11.1% commented on stains from pesticide use on fruits and 11.1% commented of worm presence in the fruits.

4.4.9 Improving the Quality of the Tomatoes Fruits Produced

Figure 4.11 shows ways of improving the quality of tomato fruits. From the survey, 50% of the buyers interviewed indicated that using improved seeds could improve the quality of fruit produced, 40% of the buyers suggested training of farmers in proper pesticide use and finally 10% of the buyers were of the view that farmers should plant at the right time.

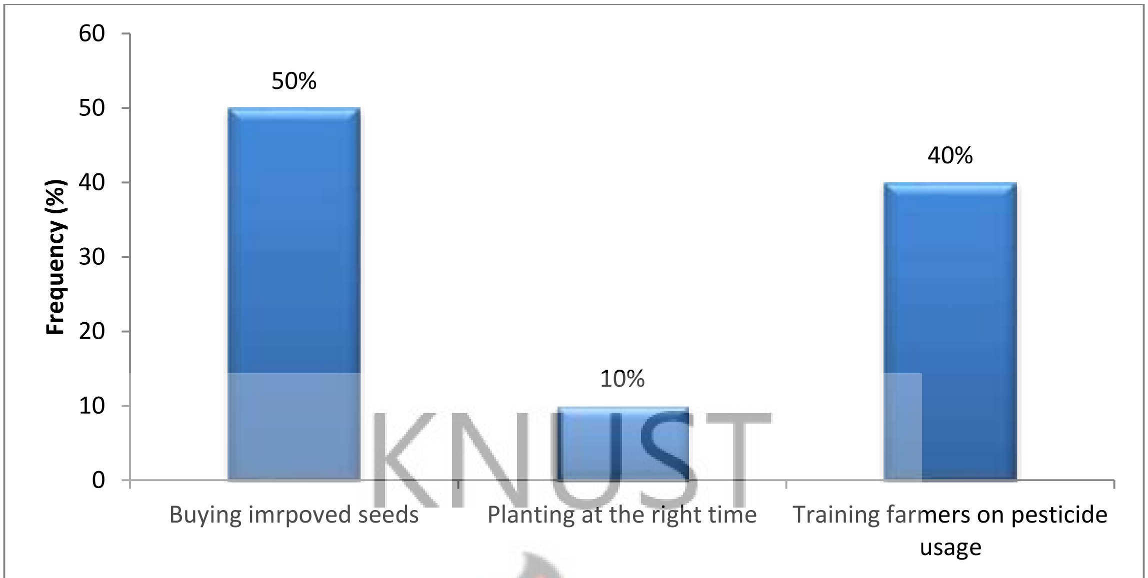

Figure 4.11: Ways of improving the quality of tomato fruits produced

4.5 CONSUMERS

4.5.1 Bio-data of Consumers

Table 4.29 shows the bio-data of tomato consumers in the Fanteakwa District. Majority of the consumers were female (80%) while 20% were males. Most of the consumers (55%) were aged between 20-29 years, 15% were aged between 40-49 years and 60 years above, 10% of consumers were within 30-39 years. However, 5% of consumers were aged between 50-59 years

On educational background, 60% of the consumers were educated up to the Junior High (JSS) or hold Middle School Leavers Certificate as their highest qualification, 15% had secondary level education, 10% had primary level education while only 5% had tertiary education. However, 10% of the consumers had no formal education.

Table 4.29: Bio-data of Customers

		Frequency	Percentage
Sex	Male	4	20
	Female	16	80
Total		20	100
Age	20-29 years	11	55.0
	30-39 years	2	10.0
	40-49 years	3	15.0
	50-59 years	1	5.0
	60 years and above	3	15.0
Total		20	100.0
Education	No formal education	2	10.0
	Primary	2	10.0
	JSS/MSLC	12	60.0
	SSS	3	15.0
	Tertiary	1	5.0
Total		20	100.0

Source: Field survey, 2012.

4.5.2 Uses of Fresh Tomatoes by Consumers

Majority of the consumers interviewed (90%) indicated that they consume fresh tomatoes bought from the markets whiles 10% of the consumers did not (Figure 4.12).

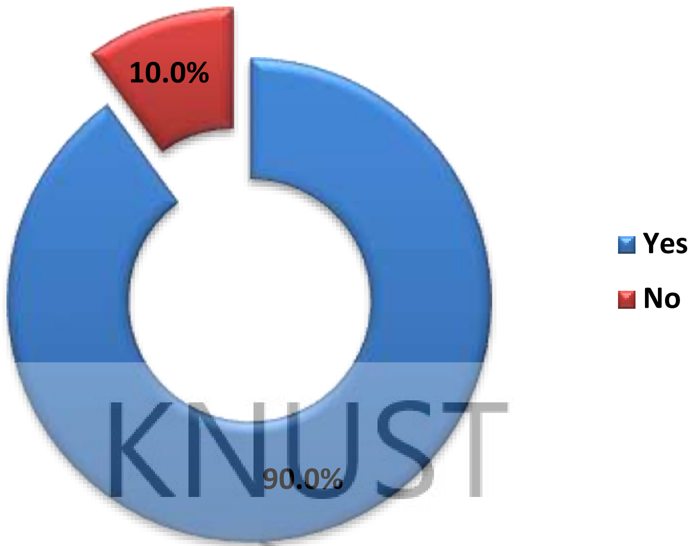

Figure 4.12: Consumption of fresh tomatoes by consumers

Figure 4.13 shows the forms in which the tomatoes were used by the consumers. From the survey, 50% of the consumers interviewed indicated that they usually ground the fresh tomato before using while 5% indicated that they chop the tomato fruit before using. Forty-five per cent of the consumers interviewed said that they either ground or chopped the fruit before using.

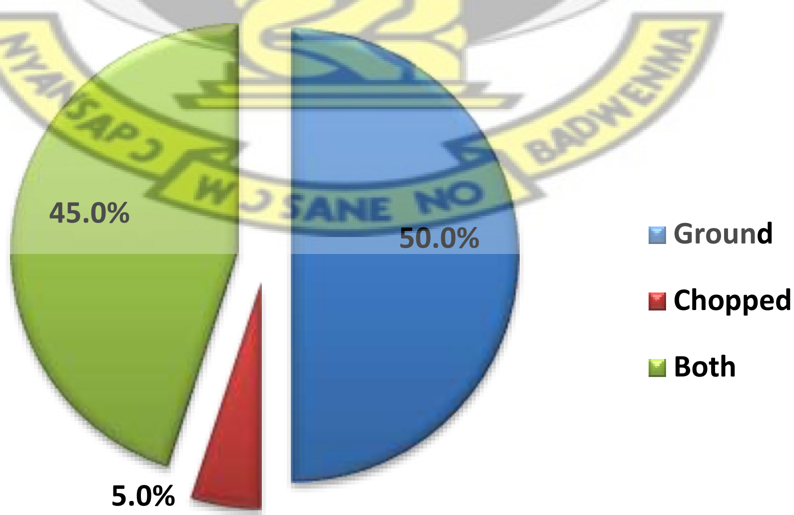

Figure 4.13: Forms in which fresh tomato are used by consumers

Some of the uses consumers put fresh tomatoes into are presented in Figure 4.14. The consumers interviewed (31.7%) indicated that they used the fresh tomato fruit in soups and stews. Others grind or chop the fresh tomato before consuming (28.6%) while 7.9% of the consumers used the fresh tomato fruit in salads.

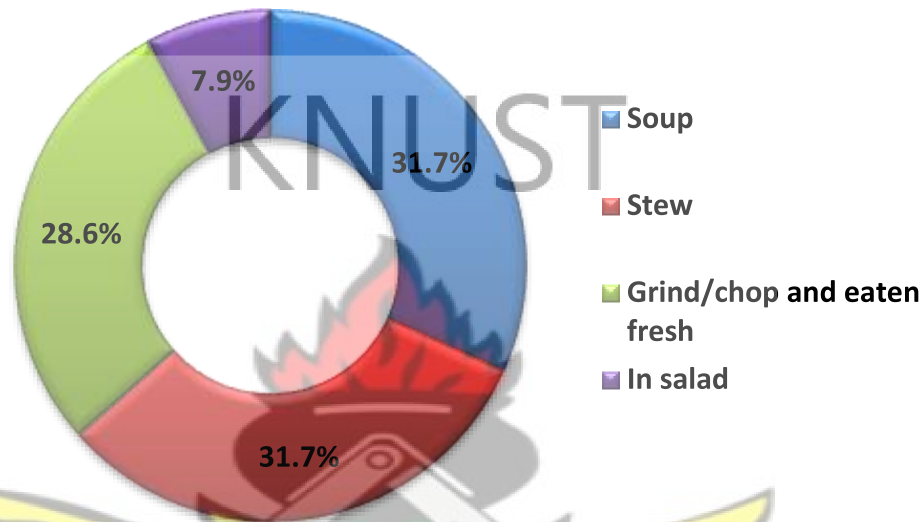

Figure 4.14: Some uses of fresh tomatoes in the Fanteakwa District

4.5.3 Quality of Tomatoes Preferred by Consumers

All the consumers interviewed indicated that they normally bought tomato fruits that were fully ripe from the markets. Qualities looked for when buying tomatoes are presented in Figure 4.15. The qualities looked for included colour (50%), firmness (18.8%), size of the fruits (15.6%), how fresh the fruit are (12.5%) and finally, the level of damage or bruises on the fruits (3.1%).

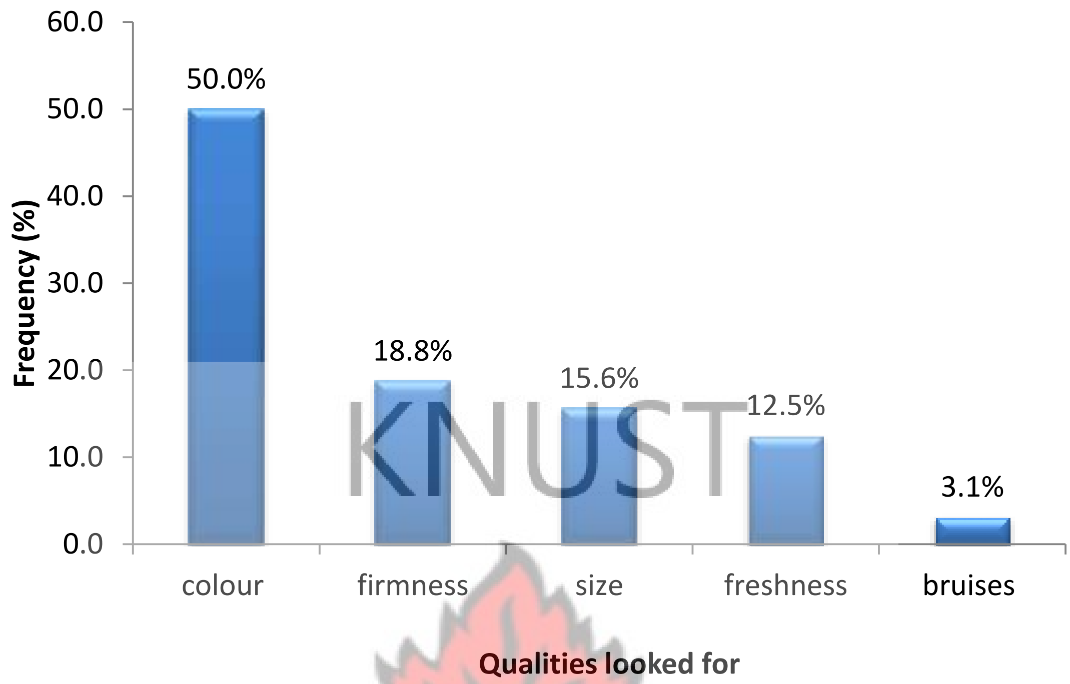

Figure 4.15: Qualities looked for during tomato purchases in the Fanteakwa District

4.5.4 Storage Practices Adopted by Consumers

All the consumers interviewed indicated that they normally store the tomato fruits they buy. Storage methods adopted and used by the consumers included keeping fruits in plastic bowls (30.4%), on cemented bare floor (30.4%), in refrigerators (26.1%) and polythene bags (8.7%). However, 4.3% of the consumers boiled the tomato fruits to preserve it from rotting (Figure 4.16).

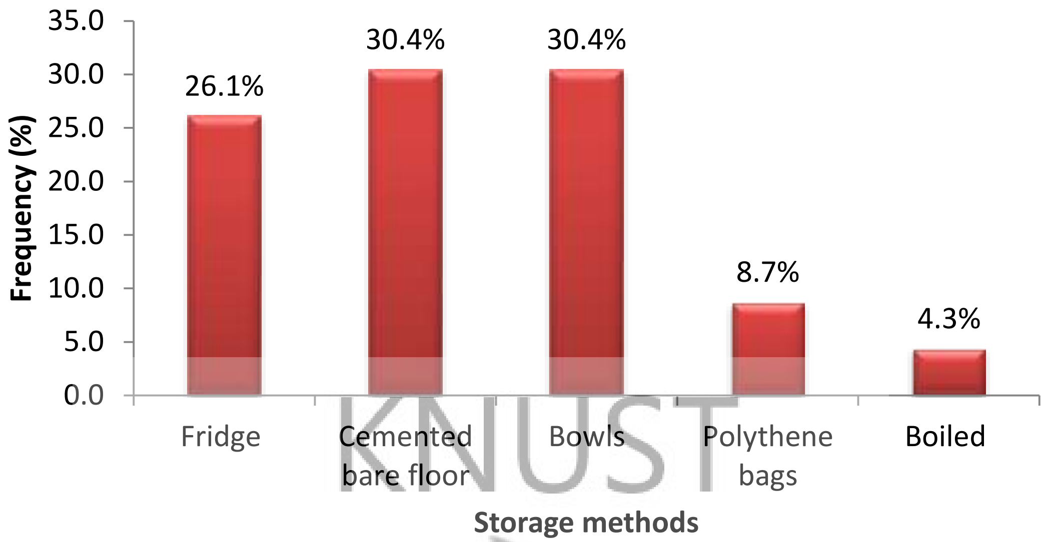

Figure 4.16: Storage methods used by consumers in the Fanteakwa District

When consumers were asked about the quality of the tomato fruits after storage (Figure 4.17), 44.4% of the consumers indicated that the fruits still looked fresh after storage, 27.8% said the fruits becomes soft after storing, 22.2% indicated that the fruits rot in storage and 5.6% of the consumers mentioned rodent attack on the tomato fruits.

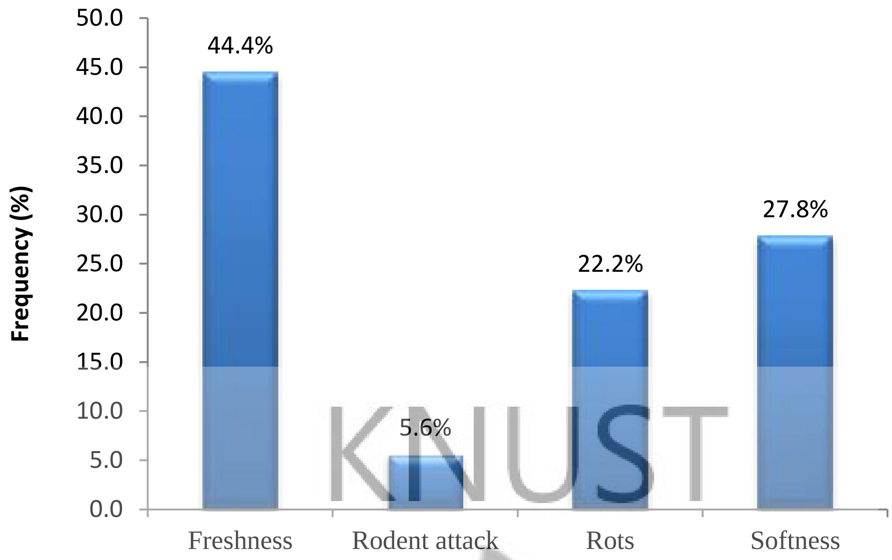

Figure 4.17: Quality of tomatoes after storage by consumers

4.5.5 Complications Experienced after Tomato Consumption

Again when consumers were asked whether they experienced some form of complication when they consumed the tomatoes, majority of the consumers interviewed said 'no' they did not have any complications whereas 5% of the consumers interviewed indicated that they had diarrhoea after consuming the fresh tomatoes (Figure 4.18).

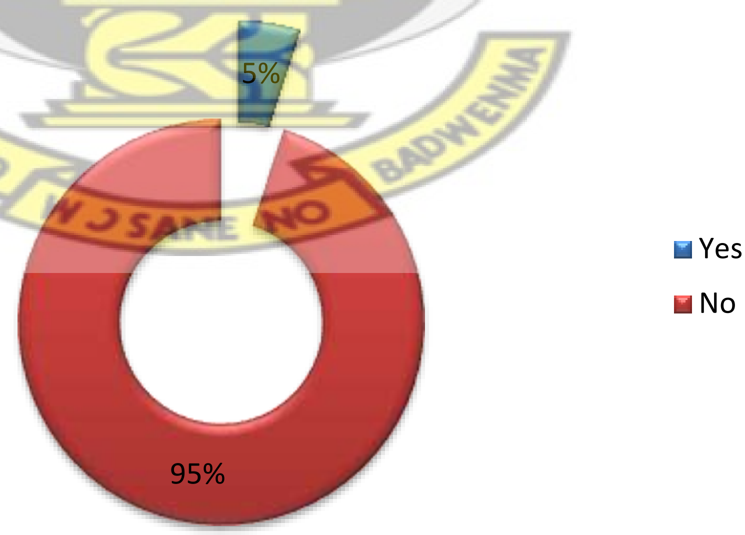

Figure 4.18: Complications after consumption of fresh tomato by Consumers

4.6 Multi-Pesticide Residue Levels in Tomato

Results of the multi-pesticide residue analyses of tomato fruits collected from the Fanteakwa district are presented in Appendix 1c and Figure 4.19. In all, twenty-three (23) different pesticide compounds were detected in the tomato fruits sampled. Out of this, Delta-HCH was found to be above the recommended Minimum Residue Level of 0.05mg/kg for export for both fruits kept in ambient condition and in refrigerators.

Beta-HCH, Gamma-HCH, Heptachlor, Aldrin,Allethrin, Gamma-Chord, Dieldrin,Endrin, PP-DDT, PP-DDD,Fenpropathri,Methoxyclor, Lambda Cyhalothrin, Permethrin, Cyfluthrin, Fenvalerate and Deltamethrin were found to be below the recommended Minimum Residue Level of 0.05mg/kg for export for both fruits kept in ambient condition and in refrigerators. For α-Endosulfan, β-Endosulfan and Endosulfan Sulphate, Bifenthrinand Cypermethrin were also found to be below the recommended Minimum Residue Level of 0.2mg/kg for export for fruits kept in ambient condition and in refrigerators.

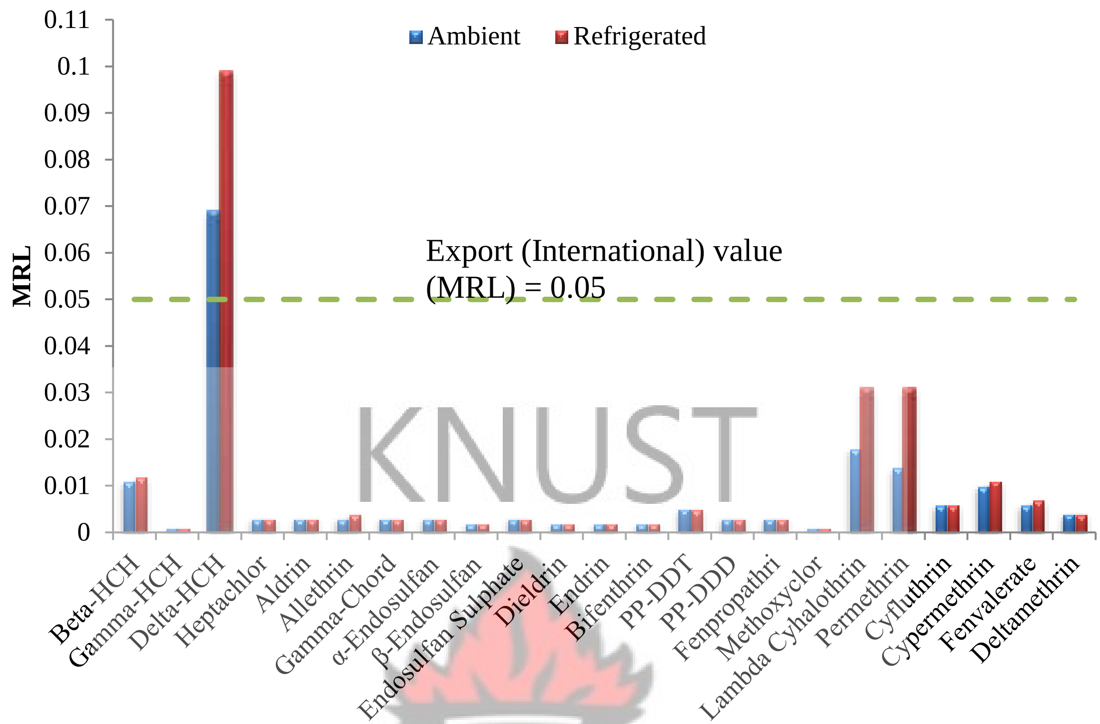

Figure 4.19: Pesticide residue levels in Tomatoes from the Fanteakwa District

Statistically, significant differences (P<0.00) were observed between tomato fruits kept under ambient conditions and fruits kept in the refrigerators for Delta-HCH (t=24.68, p=0.00), Lambda Cyhalothrin (t=27.58, p=0.00) and Permethrin (t=36.06, p=0.00).

However, no significant differences were observed among the rest of the pesticide residues detected (P>0.05) (see Appendix 1d).

5.0 DISCUSSION

5.1 Distribution of Respondent by Category

The study conducted covered four different categories of respondents that consisted of 100 farmers (71.4%), 10 agrochemical sellers (7.1%), 10 buyers (7.1%) and 20 consumers (14.3%) this indicates that in the tomato value chain activities there were several actors within the value chain.

5.2 Bio-data of Farmers

The survey revealed that, tomato cultivation was dominated by male farmers compared to female farmers. This could be attributed to the fact that tomato cultivation is labour intensive and certain cultural practices such as regular pesticide application for pest managements, weeding and raising of mounds basically falls in the domain of the male farmers while the female would need to invest a lot of money in labour thus making it an expensive venture for them. The survey also showed that the active year group of farmers was within the age range of 40-49 years which falls in the active working population of the country. This gives an indication that tomato cultivation was dominated by the middle aged class rather than the youth who might not be interested in tomato cultivation but in other vegetables like cabbage, onions and garden eggs which are popularity in the study area. Education is a major key to development through decision making. The study revealed that basic education (Junior High School and Middle School Leavers Certificate holders) was their highest educational level attained by majority of the farmers. Only a small proportion of the farmers had no form of formal education. This means that majority of the farmers could read and write.

5.3 Farm Characteristics

5.3.1 Varieties of Tomato Grown by Farmers

The result of the study also showed that nine different tomato varieties were grown, as has been reported in previous studies by JICA/IDA in 2004, but the majority of the farmers cultivated Power and Pectomech. The two varieties were the most preferred varieties by buyers to meet consumers demand for qualities such as colour, firmness and the thickness of the fruits mesocarp that made them store much better compared with the other varieties as reported by the buyers. The other varieties even though did not have thicker mesocarp were also grown as the respondent complained they could not afford to buy the seeds of the preferred varieties because the seeds were expensive.

5.3.2 Pest Management Practices during Crop Production

The study conducted indicated insecticides were mostly used because insects were of serious challenge to the farmers in the study area. Dinham (2003) estimated that 87% of farmers in Ghana used pesticides to control pest and disease on their vegetables. The majority of the respondents sprayed their farms to control fruit borer, leaf worms, whitefly and aphides. From the results, 38 different types of pesticides were used in pest management with insecticides largely used compared to fungicides. In another study carried out in Zimbabwe by Sibanda *et al*. (2000), it was reported farmers mainly focused on the use of synthetic pesticides to control pests. Probably farmers only focused on the use of insecticides as the only remedy to effectively control pest and diseases on their tomato farms and this seem to be on a try and error bases. The use of so many different pesticides and combinations could imply that farmers need regular training on pesticides selection in relation to specific pest control, pesticide mode of action and pre-harvesting intervals for various pesticides, handling with illustrations, teaching aids and in simple language due to the educational level of the farmers.

5.4 Sources of Pesticide Used by Farmers

From the result of the survey, majority of the farmers indicated that they bought their pesticide from Agrochemical shops. Nonetheless, others bought pesticides from unapproved sources such as from moving vehicles and peddlers who sell on table tops in the markets and also from friends due to cheaper prices. Pesticide usage by farmers seem to be highly influenced by wholesalers and distributors through promotional sales and pesticide vendors who did business right in the farming communities with the sole motive of achieving high pesticide sales and making more profits without considering the farmers health. Work also done by Snoo *et al.* (1997) and Epstein and Bassein (2003) showed that in many developing countries, the choice of pesticide usage by most farmers is usually influenced by the pesticide distributors.

5.5 Choice of Pesticide Used by Farmers

Majority of farmers in the study area selected their pesticide based on their effectiveness in pests and disease control while others selected pesticides with the hope that they will help keep their tomato fruits firm, enhance the colour of tomato and also because they were affordable. This has led to the use of many different pesticides in tomato cultivation thereby posing various health threats to both the farmers and consumers.

5.5.1 How Pesticides were Measured by Farmers

The result from the study indicated that majority of tomato farmers used spoons, pesticide lids, and empty cans to estimate pesticides to be used while only few used calibrated measuring cups. These items of measuring were similar to what Ntow (2008) reported. He reported that to measure pesticides, some farmers used spoons, cans, measuring cylinders and bottles resulting in the use of wide ranges of pesticide rates being applied to crops. This most likely, led to the use of low concentrations of pesticides for the control of insects, the ineffective targeted pest control and the likely development of resistance and the farmers not complying with Good Plant Protection practices.

5.5.2 Application of Pesticides during Harvesting

The use of pesticide during the harvesting periods was observed with majority of the farmers and they assigned various reasons as to why they applied pesticides during the harvesting period. Some indicated that the application enhanced fruit firmness, gave better fruit protection, improved fruit colour and ripening to meet market days. For the few farmers who did not apply pesticides during harvesting, they indicated that the pesticides were not safe for consumption, that pesticides takes time to break down, other farmers advised against it and that it was also against the directive of the Ministry of Food and Agriculture (MoFA) education. The result also indicated that farmers applied fungicides and insecticides up to the point of harvest and during harvest, presuming pesticides residues left on the fruits after harvest will continuously increase the shelf life of the fruits. Majority of the farmers had limited linkage with agricultural extension services and also lacked the commitment to consult Agricultural extension agents leading them to attempt various means in the use of pesticides when faced with pest management challenges. The lack of know how in good plant protection practices, couple with the low extension-farmer ratio in the study area contributed to the misuse of the chemicals. In previous studies conducted by Ngowi (2003), it was revealed that farmers were not receiving agricultural extension services hence have attempted various means, especially in pesticide use, when dealing with problems but were constrained by the lack of appropriate knowledge.

5.5.3 Pesticides Combination (Cocktails) Used by Farmers

The result from the studies indicated that 84% of the farmers forming the majority, mixed different pesticides when spraying their tomato crop in the field while only 16% did not. The farmers were not aware that there are no safe chemicals but there are only safe ways to use chemicals to ensure food safety. Medina (1998) questioned the combinations and indiscriminate use of pesticide by farmers. Again, Biney (2001), in his research mentioned that practice of farmers using pesticide cocktails, particularly of insecticides, which may likely contribute to the insurgence of insect pest infestation management challenges in tomato cultivation in Ghana. Danso *et al.* (2002), also asserted that the use of high levels of pesticides is very harmful and even though integrated pest management and organic agricultural strategies can as well be used to manage pest activities which can result in comparable yields but its adoption by farmers is not encouraging for various reasons.

5.5.4 Number of Pesticide Used in Cocktail Preparation

The number of pesticides used in mixes or cocktails obtained from the results indicated majority of the farmers interviewed mixed three different pesticide types when controlling pests and diseases on their tomato crops. The choice of pesticides used, according to the respondents, depended on their availability on the market, friend's advice and influence of peddlers who visited their communities. In a previous study by Smith *et al*. (2002), they observed that there was an interaction between pesticide mixtures and the water mineral content that influenced the efficacy of the individual pesticides against fungal pathogens and insect mortality, and some tank mixtures induced phytotoxicity on tomato crops.

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5.5.5 Reasons Why Farmers Mixed or Did Not Mix Pesticides

The study result indicated various reasons why farmers mixed different pesticides in the field were to save time, increase the potency of the chemicals, reduce labour, and produce disease free products. The pesticide combination by farmers probably may be based on previous knowledge on pesticides application and their effectiveness which were discussed among themselves. However, majority of farmers who did not mix pesticides felt that it was not safe to mix the pesticides since they did not know the chemical composition. Others indicated that the pesticides were already effective in controlling pests therefore there was no need to mix while the rest said that they do not mix different pesticides because the pesticides have been already formulated for effective pest control.

5.6 Pre-Harvest Interval Used by Farmers

It was revealed that the pre-harvest intervals were not adopted by the farmers. The farmers harvested within the same day or harvest within four to six days after application of pesticides. Such practices could lead to high pesticide residues in harvested fruits. The challenge of food contamination due to pesticide residue is a cause of concern for everyone therefore keeping to the withholding period becomes very important. Every pesticide used has a waiting or pre-harvest interval which is defined as the number of days that is require to lapse between the day of application and time of harvest for pesticide residues to fall below acceptable levels establish for the various crops. What farmers were not aware the waiting periods for various pesticides differ from pesticide to pesticide and crop to crop

5.7 Use Protective Clothing during Pesticide Application

From the result, it was indicative that the farmers did not completely protect themselves from the hazards of pesticide contamination. The best protection that majority of the farmers had were field boots, trousers, used long sleeved shirts, nose mask, and goggles while a few of them used short sleeved shirts and shorts when spraying. This practice may have exposed those tomato farmers to various health hazards of the pesticides being used. Some reasons advanced for not using protective clothing were that they were not comfortable to wear, it was too costly to buy, were not necessary, not available on the markets, were not good protectors and that parts of the body were still exposed when being used. Pesticides are poisonous and are meant to kill, and as farmers get exposed to different formulations which enter to their systems, through inhalation and skin contacts through mishandling, which may lead to acute or chronic exposures, with adverse health consequences within the study area. Previous work done by Santo, *et al. (*1998) suggested that pesticides can be fatal if inhaled or absorb through the human skin, even though their effects may be delayed. There is, however limited information on whether farmers suffered any effect from the mixtures used in the study area.

5.8 Self-Reported Pesticide Poisoning Symptoms by Farmers

The survey revealed self-reported signs of pesticide poisoning by farmers. Most of the farmers reported of skin problems such as burning and rashes, neurological system disturbances such as dizziness and headache, severe sneezing and general weaknesses which have also been reported in other studies conducted by Arendse, *et al.* (1989). The farmers perceived that poison symptoms were normal after spraying. Also similar studies in Indonesia by Kishi *et al.* (1995) and in Cote d'lvoire by Ajayi (2000), did report that pesticide sprayers did accept some level of illnesses as normal when using pesticides and ended up not reporting the symptoms in official health centres for medical examination and treatments. Reported health cases on acute respiratory disease and skin disease at the Fanteakwa Government Hospital between (2009 to 2011) on males aged between 30-49 years who also fell within the active age group in tomato production, showed that acute respiratory disease was the most common illness reported in the district than skin diseases over the years. The highest incidence of acute respiratory disease and skin disease were recorded in 2011 Even though it could not be ascertained that the reported causes on acute respiratory and skin diseases were pesticide-induced, they (pesticide usage) were suspected to be the cause.

5.9 Registration Status of Agrochemical Shops

From the result, only 10% of the Agrochemical shops were registered with the Environmental Protection Agency (EPA) to legally sell pesticides. This situation was a result of majority of them perceiving it as a lucrative business to engage in. Also majority of them had only basic education and so did not understand the challenges and hazards associated with use of pesticide. Therefore, this has led to individuals that have no training to sell pesticides. Agro chemical sellers have crucial rolls to play in pesticide handling in the study area to compliment the education of farmers in the correct use of pesticides.

5.9.1 Pesticides Wrongly Sold to Farmers Based on Mode of Action

The results indicated Lambda Super 2.5EC, Optima, Polythrine, Durban, Sunpyrifios and Termex which are contact insecticides were wrongly sold as systemic insecticides to tomato farmers. Champion which is a contact fungicide was sold as a contact insecticide. Nordex, Folpan and Top Cop were also wrongly sold as systemic fungicides but were in fact contact fungicides. The chemical sellers were constrained by the lack of appropriate knowledge but the interest in achieving more sales of their pesticide caused them to sell. There seem to be no monitoring mechanisms in place to regulate chemical sellers' activities which were aiding the misuse of pesticides Ntow in 1998, also indicated that there is almost non-existence of pesticide residue monitoring in Ghana.

5.9.2 Farmers Ability to Explain Problem Clearly to Agro Chemical Sellers

Results also indicated that most of the chemical sellers interviewed 70% indicated that farmers were not able to express themselves or clearly explain their problems to them. This situation makes it difficult for the agro chemical sellers to assist the farmers. In such difficult situation the chemical sellers who themselves have some form of challenges may end up selling pesticides that might likely not solve the farmers challenges.

5.9.3 Pesticide Outlets Used by Farmers

All the chemical sellers interviewed indicated that tomato farmers bought pesticides from pesticide peddlers who were untrained and sold from moving vehicles, from the local market where prices were likely to be cheaper and from other farmers' friends who sold pesticides on table tops in the communities. In the study area pesticide usage seems to be highly influenced by pesticide peddlers who carried out their transaction right in the farming communities and are only interested in achieving large sales and profits. In a previous study by Snoo *et al.* (1997), they observed that this is a typical situation in many developing countries where the choice of pesticide to be used by farmers is influenced by the suppliers. This situation may have also contributed to pesticides being sold wrongly, mishandled and misused in the study area. The chemical sellers indicated, from the result, that adulterated, expired, wrong pesticides, unlabelled and with inadequate information were likely being to be sold to the tomato farmers.

5.10 How Buyers Saw the Use of Pesticides by Farmers

The study revealed that majority of the buyers, even, though were aware of food safety related issues such as pesticide contaminations, still perceived the use of pesticides as good and that it helped the plant to grow well, enhance fruit setting and improved fruit appearance as well as helped the fruits to store longer. Others, also, thought that excessive use of pesticides contributed to reduced shelf life of the tomato fruits and also stated that information received from consumers on food safety did influence their decisions and choice of tomato fruits they bought.

5.11 Complications Experienced after Tomato Consumption

When consumers were asked whether they experience some form of complication when they consume the tomatoes from the study area, majority of the consumers interviewed indicated that they did not have any complications whereas only few of the consumers interviewed indicated that they had diarrhoea after consuming some fresh tomatoes fruits. This could mean consumers were not able to link complication to the tomato fruits consumed since they ate these with other food substances or it could be that consumers may have been putting the tomato fruit through some form of processing which is likely to break down pesticide residues. Holland *et al.* (1994) stated that the behaviour of residue in storage and processing can be rationalized in terms of its physiochemical properties of the pesticide and the nature of the process.

5.12 Multi-Pesticide Residue Levels in Tomatoes

The second phase of the research which involved the analysis of residue levels indicated the presence of twenty-three (23) different pesticide compounds in the tomato fruits sampled. Out of this, Delta-HCH was found to be above the recommended Maximum Residue Level (MRL) of 0.05mg/kg for international export values for both fruits stored under ambient and refrigerators conditions. Beta-HCH, Gamma-HCH, Heptachlor, Aldrin,Allethrin, Gamma-Chord, Dieldrin,Endrin, PP-DDT, PP-DDD,Fenpropathrn,Methoxyclor,LambdaCyhalothrin,Permethrin,Cyfluthrin,Fenvalerate , α-Endosulfan, β-Endosulfan, Endosulfan Sulphate and Deltamethrin were found to be below the recommended Minimum Residue Level of 0.05mg/kg for export for both fruits kept in ambient and in refrigerators conditions. While Bifenthrinand Cypermethrin were also found to be below the recommended Maximum Residue Level of 0.2mg/kg for export for fruits kept under ambient and refrigerators conditions. Looking at the misuse and misapplications, it is possible that the stated active ingredients (a.i) in these chemicals may have been below the stated level that is why the residue levels could be below the maximum residue limits (MRLs).

6.0 SUMMARY, CONCLUSION AND RECOMMENDATION

6.1 SUMMARY OF FINDINGS

The study was in two parts i.e. a field survey and a laboratory work as the second phase. From the field study, 38 different pesticides were widely used of which 71.1% were insecticides and 28.9% fungicides. Majority of the farmers mixed different pesticides when spraying their tomato crops. The farmers were not aware that there are no safe chemicals but there are only safe ways to use chemicals. Majority of the farmers reported of skin rashes and burning sensations, dizziness, headache, severe sneezing and general weakness. There were also reported health cases on acute respiratory diseases and skin disease at the Feanteakwa Government hospital between 2009 to 2011 by males aged between 30 to 49 years who fell within the active age group of farmers in tomato cultivation. The hospital reports showed that acute respiratory disease was the most common illness reported in the district than skin diseases over the years. The highest incidence of acute respiratory disease and skin disease were recorded in 2011. Even though it could not be ascertained that the reported cases were pesticide induced, they (pesticide usage) were suspected to have played a part.

Majority of agro-chemical shops in the district were not registered with the Environmental Protection Agency (EPA). Pesticides were also wrongly sold to farmers based on their mode of action. The farmers bought pesticides from chemical peddlers who were not trained, moving vehicles and from their farmer friends. The farmers harvested within the same day or within four to six days after application of pesticide, presuming that pesticides residues on the fruits after harvest will continuously increase the shelf life of the fruits. What the farmers did not know was that the awaiting periods for various pesticides differ from pesticide to pesticide and crop to crop.

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Majority of the buyer perceived the use of pesticides as good but its excessive use needed to be regulated. The majority of consumers used the tomatoes in preparing soup or stew by either grinding or chopping them and were not able to link health problems complication to the tomato fruits consumed since they consumed the fruits together with other food substances.

Findings from Laboratory analysis revealed the presences of organochlorines (60.9%) and pyrethriods (39.1%) pesticides residues in tomato fruits from the study area. These percentages were derived from 23 different pesticide residues detected in the laboratory but not mentioned in any of the farmers' answers to the questionnaires from the first phase of the study. However, pesticides listed from survey results did not include any organochlorines compounds. The source of the detected organochlorines could not be readily traced but this occurrence could either be due to wrong information from farmers about pesticides used, wrong labelling or adulteration of the chemicals either by paddlers, importers, middlemen or manufactures. Chlorinated pesticides are of global concern due to their persistence, toxicity to humans and animals and their high bioaccumulation factor (van Emden, 1989).

Sampled fruits from the farmers kept under two different storage conditions (Ambient and Refrigerated) showed significant differences ($P<0.00$) in pesticide residue for the following: Delta-HCH ($t=24.68$, $p=0.00$), Lambda Cyhalothrin ($t=27.58$, $p=0.00$) and

Permethrin (t=36.06, p=0.00). for each of these compounds they were significantly higher in concentrations under refrigeration than under ambient conditions. However, no significant differences were observed among the rest of the pesticide residues detected (P>0.05). From the result of the study, storing tomato fruits for 10 days under ambient (24^0C) condition could break down pesticide residue down compared to the refrigerated (5±4ºC) storage which could be due to photolytic decay as a result of exposure to high temperature and light which can break the intermolecular bonds in the pesticides easily (.Kurenranchie-Mensah *et al*.,2011)

6.2 CONCLUSIONS

Tomato farmers of the Fanteakwa District are mostly men of age ranging between 30 to 49 years. They have basic school education. Knowledge about pesticide use and good plant protection practices is very low.

Detected pesticide residue on tomato fruit samples from farmers farm in the Fanteakwa district were not a true reflection of what farmers thought they had purchased for pest control. They were mainly organochlorines. Farmers' resorted to the used of pesticide cocktails as a result of improper measurements of pesticide doses and potency of pesticides they have being using at each application and these may be mostly due to their lack of knowledge. They also admitted that there were some side effect on their health but perceived them to be normal and temporal and did not need medical attention.

Education, training on various pest management strategies, use of protective clothes and safe pesticide handling need to be advocated, established and strengthened among farmers groups and chemical sellers associations. Tomato fruits may be stored under ambient temperature for few days before storage in the refrigerator or consumed since the result revealed that pesticide residue in tomato fruits breaks down faster compared to those stored under refrigerated conditions.

6.3 RECOMMENDATION FOR FUTURE STUDIES

i. Tracing the sources of the organochlorines as to whether they were from contamination of the soil or adulteration from the manufactures.

ii. Health impact study on detected organochlorines.

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APPENDICE

Appendix 1a: WHO Classification of Pesticides used and their Registration Status in Ghana

TRADE NAME	ACTIVE INGREDIENT	PRE-HARVEST INTERVAL AS INDICATED ON PESTICIDE LEBELS	WHO CLASS	USE (CONTROL PEST /DISEASE ON CROP)	REGISTRATION STATUS IN GHANA
Polythrine	Cypermethrin (PY)	4 -days	II	Non-systemic insecticide for vegetable pest	PLC
Lambda	Lambda cyhalothrin 2.5EC (PY)	2-3days	II	Non-systemic insecticide for vegetable pest	FRE
Power	Lambda cyhalothrin 2.5EC (PY)	2-3days	II	Non-systemic insecticide for vegetable pest	FRE
Karate	Lambda cyhalothrin 2.5EC (PY)	2-3days	II	Non-systemic insecticide for vegetable pest	FRE
Bossmate	Lambda cyhalothrin 2.5EC (PY)	2-3days	II	Non-systemic insecticide for vegetable pest	FRE
Kombat	Lambda cyhalothrin 2.5EC (PY)	2-3days	II	Non-systemic insecticide for vegetable pest	FRE
Wireko	Lambda cyhalothrin 2.5EC (PY)	2-3days	II	Non-systemic insecticide for vegetable pest	FRE
Master	Lambda cyhalothrin 2.5EC (PY)	2-3days	II	Non-systemic insecticide or vegetable pest	FRE
Thiodan	Endosulphan (OC)	1day	II	Non-systemic insecticide for vegetable pest	FRE
Diazinon	Diazinon (OP)	10-14days	II	Non-systemic insecticide for vegetable pest	PLC
Diazol	Diazinon(OP)	10-14days	II	Non-systemic insecticide for vegetable pest	PLC

TRADE NAME	ACTIVE INGREDIENT	PRE-HARVEST INTERVAL AS INDICATED ON PESTICIDE LEBELS	WHO CLASS	USE (CONTROL PEST /DISEASE ON CROP)	REGISTRATION STATUS IN GHANA
Akate -suro,	Diazinon(op)	14days	II	Non-systemic insecticide for cocoa pest	FRE
Attack	Emamectine Benzoate	3-14days	II	Insecticide; for pest of vegetables	-
Dimethorate	Dimethoate (OP)	14 days	III	Systemic insecticide for crop pests	-
Confidor,	Imidacloprid	14-23day	-	Systemic insecticide: for cocoa pest	New
Considal	Imidacloprid	14-23day	-	Systemic insecticide	New
Sidalprid	Imidacloprid	14-23day	-	Systemic insecticide	New
Anti-attah,	Imidacloprid	14-21 days	III	Systemic insecticide	New
Titan	Actemiprid	21days	II	Contact insecticide	PLC
Golan	Actemiprid	3-21days	II	Contact insecticide	PLC
Cocostar	BifenthrinPrimiphos methyl	5-14days	III	Insecticide for control of cocoa pest	Banned
Furadan	Carbofuran (CARB)	3-4 months after planting	Ib	Insecticide for pineapple pest control	FRE
Deltapaz	Deltamethrin	2-14days	II	Insecticide	FRE
Keshet	Deltamethrin	2-14days	II	Insecticide	FRE
M-fos/ Termex	Chlorpyrifos (OP) Chlorpyrifos (OP)	7-14days 7-14days	II	Insecticide for various crops and public health	FRE
Dursban 4E	Chlorpyrifos (OP)	4 days	II	Insecticide for various crops and public health	FRE
Cyperdem	Cypermethrin	7-14days	II	Insecticide	FRE

TRADE NAME	ACTIVE INGREDIENT	PRE-HARVEST INTERVAL AS INDICATED ON PESTICIDE LEBELS	WHO CLASS	USE (CONTROL PEST /DISEASE ON CROP)	REGISTRATION STATUS IN GHANA
Topsin	Thiophanate- methyl (OP)	7-14 days	III	Fungicide	PCL
Nordox	Coprous Oxide	-	-	Fungicide: for diseases control in cocoa	-
Rodomil	Metalyxal+Copper	7-14days	II	Fungicide: for diseases control in cocoa	FRE
Bendazim	Carbendazim	7-15days	III	Fungicide	PCL
Diathane	Mancozeb (CARB)	3-14 days	III	Fungicide: diseases in vegetables	FRE
Fungura- HO	Copper hydroxide	7-14days		Vegetables and tree crops	FRE
Kocide,	Copper hydroxide	7-14days		Fungicide: diseases in cocoa	FRE
Champion	Copper hydroxide	3days		Fungicide: diseases in cocoa	FRE
Funguran	Copper hydroxide	3ays		Fungicide: diseases in cocoa	FRE
Defender	Copper hydroxide	3 -14days	III	Fungicide: diseases in cocoa	FRE
Top cop	Sulphur	2-14 days	III	Miticide/fungicide	PCL
FlopanFlopet and fruit trees		-	-	Fungicide: Vegetables, Legumes	PCL

Agribusiness System International MRL Status report (2007) - Tomatoes V2.0

FRE - Fully registered for use in Ghana (valid for a maximum of three years;
PCL - Provisional Clearance in Ghana (valid for a maximum of one year;.
OC – Organochlorine; **PY** – Pyrethriod; **CARB** – Carbamate; **OP** – Organophosphate; **WHO** - Toxicity classes;
Ib - Highly toxic; **II**-moderately hazardous; **III**- slightly hazardous; **New**- new active substance under consideration in Ghana

Appendix 1b: Summary of Active Ingredients of pesticide cocktails used by Farmers

Pesticide Cocktail (active ingredient)	Common Trade names
Lambda cyhalothrin** + Mencozeb+ Lambda cyhalothrin**	Wireko**+ Dithane,+Power**
Thiophanate-methyl +Mancozeb+ Sulphur	Topsin+ fungura+sulpher 80
Cypermethrin	Polythrine
Thiophanate-methyl + Mencozeb+Lambda+Copper hydroxide	Topsin+ Diathane+ Power, Fungura- HO
Thiophanate-methyl +Mencozeb+Lambdacyhalothrin +Metalyxal	Topsin,+Diathane+ Power+ Rodomil
Sulphure+ Thiophanate-methyl +Lambda+Copper hydroxide	Topcop+Topsin+Lamda+champion
Sulphur**+ Mencozeb+Sulphur**	Top cop**+ Dithane+sulper 80**
Sulphur+CopperOxide+Lambdacyhalothrin	sulfa 80+kocide+ Lambda
Lambda cyhalothrin** +Lambda cyhalothrin**+ Deltamethrin	Power**+ kombact**+keshet
Cypermethrin+ Chloropyrifos	Polythrine+ Termex
Lambda cyhalothrin + Coprous Oxide	Bossmete, + Nordox
Lambda cyhalothrin +Acetamiprid+Diazinon	Kcombat + Golan+ Diazinon,
Lambda cyhalothrin+Deltamethrin	Lumbda+ keshet
Lambda cyhalothrin+Imidacloprid**+ Imidacloprid**	Lumbda, Considal**, Anti-Attah**
Lambda cyhalothrin+Mancozeb	Lamda+Diethine
Copper Oxide + Thiophanate-methyl	Kocide+Topsin,
Lambda cyhalothrin +Mencozeb	Master,+Diathine
Mancozeb**+ Thiophanate-methyl +Copper hydroxide +Mancozeb**	Dithane**+topsin+kocide+Benco**
Mencozeb +Dimethoate	Dithane+wireko+ Dimethoate
Mencozeb + copper oxide + Imidacloprid	Dithane+Kocide+ Confidor

Pesticide Cocktail (active ingredient)	Common Trade names
Mencozeb + Thiophanate-methyl + Copper hydroxide oxide	Dithane+ Tosin + kocide
Sulphur + Lambda cyhalothrin +Metalyxal + Folpet	Sulphur80+Power+Redomil+ Folpan
Mencozeb + Copper hydroxide	Dithane+ Kocide
Mencozeb +Cypermethrin+ Lambda cyhalothrin	Dithane+ polythene+karate
Mencozeb +Lambda cyhalothrin + Thiophanate-methyl	Dithane+ karate+ topsin
Mencozeb+ Lambda cyhalothrin**+ Lambda cyhalothrin**+ Copper hydroxide	Dithane+ karate**+ Lambda**+Kocide
Mancozeb +Emamectine Benzoate + Carbendazim	Dithane+ attack+,Bendazim
Mancozeb + Emamectine Benzoate + BifenthrinPrimiphos methyl +Chloropyrifos	Dithane+, Attack + Cocostar + M-Fos
Mancozeb +Copric hydroxide +copper oxide + Sulphur	Diathane+ Champion+kocide+sulfa 80
Chloropyrifos + Mancozeb+ Acetamprid + Diazinion	Termex+,dithane + Golan+ Diazinon
Chloropyrifos+ Emamectine Benzoate+ Lambda cyhalothrin	Dursban,+attack+kombat
Diamethorate+Acetamprid+ Diazinon	Cydem+Titan+AkateSuro
Imidacloprid+ Mancozeb + Copper hydroxide	Confidor+dithane+ champion
Imidacloprid	confidor
Lambda cyhalothrin+ Imidacloprid	Bossmate+confidor

**(Pesticides with Same Active Ingredients)

Appendix 1c: Estimated average daily intake and hazard index for tomato

Active Ingredient	Ambient	Refrigerated	Acceptable Dietary Intake (ADI) - Mg/kg/bw	Estimated Average Daily Intake		Hazard Index	
				Ambient	Refrigerated	Ambient	Refrigerated
Beta-HCH	0.011	0.012	0.1	0.0004	0.0004	0.00	0.00
Gamma-HCH	0.001	0.001	0.001	0.0000	0.0000	0.04	0.04
Delta-HCH	0.069	0.099	0.01	0.0026	0.0037	0.26	0.37
Heptachlor	0.003	0.003	0.0001	0.0001	0.0001	1.11	1.11
Aldrin	0.003	0.003	0.0001	0.0001	0.0001	1.11	1.11
Allethrin	0.003	0.004	0	0.0001	0.0001	0.00	0.00
Gamma-Chord	0.003	0.003	0	0.0001	0.0001	0.00	0.00
α-Endosulfan	0.003	0.003	0.006	0.0001	0.0001	0.02	0.02
β-Endosulfan	0.002	0.002	0.0001	0.0001	0.0001	0.74	0.74
EndosulfanSulphate	0.003	0.003	0	0.0001	0.0001	0.00	0.00
Dieldrin	0.002	0.002	0.0001	0.0001	0.0001	0.74	0.74
Endrin	0.002	0.002	0.0002	0.0001	0.0001	0.37	0.37
PP-DDT	0.002	0.002	0.01	0.0001	0.0001	0.01	0.01
PP-DDD	0.005	0.005	0.006	0.0002	0.0002	0.03	0.03
Bifenthrin	0.003	0.003	0.02	0.0001	0.0001	0.01	0.01
Fenpropathrin	0.003	0.003	0.03	0.0001	0.0001	0.00	0.00
Methoxyclor	0.001	0.001	0.1	0.0000	0.0000	0.00	0.00
Lambda Cyhalothrin	0.018	0.031	0.005	0.0007	0.0011	0.13	0.23
Permethrin	0.014	0.031	0.05	0.0005	0.0011	0.01	0.02
Cyfluthrin	0.006	0.006	0.02	0.0002	0.0002	0.01	0.01
Cypermethrin	0.01	0.011	0.05	0.0004	0.0004	0.01	0.01
Fenvalerate	0.006	0.007	0.02	0.0002	0.0003	0.01	0.01
Deltamethrin	0.004	0.004	0.001	0.0001	0.0001	0.15	0.15

Appendix 1d: Pesticide residue levels in Tomatoes from the Fanteakwa District

Active Ingredient	Residue Levels		Minimum Residue Level (MRL)*	Acceptable Dietary Intake (ADI) **Mg/kg/bw
	Ambient (24ºC)	Refrigerated (5±4ºC)		
Beta-HCH	0.011	0.012	0.05	0.1000
Gamma-HCH	0.001	0.001	0.05	0.0010
Delta-HCH	0.069	0.099	0.05	0.0100
Heptachlor	0.003	0.003	0.05	0.0001
Aldrin	0.003	0.003	0.05	0.0001
Allethrin	0.003	0.004	0.05	-
Gamma-Chord	0.003	0.003	0.05	-
α-Endosulfan	0.003	0.003	0.50	0.0060
β-Endosulfan	0.002	0.002	0.50	0.0001
Endosulfan Sulphate	0.003	0.003	0.50	-
Dieldrin	0.002	0.002	0.05	0.0001
Endrin	0.002	0.002	0.05	0.0002
PP-DDT	0.002	0.002	0.05	0.0100
PP-DDD	0.005	0.005	0.05	0.0060
Bifenthrin	0.003	0.003	0.20	0.0200
Fenpropathrin	0.003	0.003	0.05	0.0300
Methoxyclor	0.001	0.001	0.05	0.1000
Lambda Cyhalothrin	0.018	0.031	0.05	0.0050
Permethrin	0.014	0.031	0.05	0.0500
Cyfluthrin	0.006	0.006	0.05	0.0200
Cypermethrin	0.01	0.011	0.20	0.0500
Fenvalerate	0.006	0.007	0.05	0.0200
Deltamethrin	0.004	0.004	0.05	0.0010

*Agribusiness Systems International (2007). ** Brandenberger,H. and Maes R. A.A (1997).

Appendix 1e: Two-Sample T-test for Pesticide residue levels in Tomatoes

Active Ingredient	Ambient (24ºC)	Refrigerated (5±4ºC)	df	t	P-value
Beta-HCH	0.011	0.012	4	-2.12	0.10
Gamma-HCH	0.001	0.001	4	0.00	1.00
Delta-HCH	0.069	0.099	4	24.68	0.00
Heptachlor	0.003	0.003	4	0.00	1.00
Aldrin	0.003	0.003	4	0.00	1.00
Allethrin	0.004	0.003	4	2.12	0.10
Gamma-Chord	0.003	0.003	4	0.00	1.00
α-Endosulfan	0.003	0.003	4	0.00	1.00
β-Endosulfan	0.002	0.002	4	0.00	1.00
EndosulfanSulphate	0.003	0.003	4	0.00	1.00
Dieldrin	0.002	0.002	4	0.00	1.00
Endrin	0.002	0.002	4	0.00	1.00
PP-DDT	0.005	0.005	4	0.00	1.00
PP-DDD	0.003	0.003	4	0.00	1.00
Bifenthrin	0.002	0.002	4	0.00	1.00
Fenpropathri	0.003	0.003	4	0.00	1.00
Methoxyclor	0.001	0.001	4	0.00	1.00
Lambda Cyhalothrin	0.018	0.031	4	-27.58	0.00
Permethrin	0.014	0.031	4	36.06	0.00
Cyfluthrin	0.006	0.006	4	0.00	1.00
Cypermethrin	0.010	0.011	4	-0.60	0.58
Fenvalerate	0.006	0.007	4	-2.12	0.10
Deltamethrin	0.004	0.004	4	0.00	1.00

Appendix 2a: Questionnaire for Tomatoes Farmers

This questionnaire is aimed at assessing the types of pesticides tomatoes farmers in the Fanteakwa Districts in the Eastern Region. Respondents should be confident and assured that their identity would be kept confidential. Thank you for your cooperation.

Socio- Economic Characteristics

Name of Enumerator…………………Name of District……………………

A. Respondents Characteristics

1. Gender. 1. Male (…………) 2. Female (………..)
2. Age…………
3. Name of Community……………………………………
4. Major Occupation…1 [farmer] 2. [trader] 3. [teacher] 4. [civil servant] 5. Others………………
5. Farming Experience…………
6. Educational Background **(tick)…**1 [Primary]. 2. [Jss/ Middle]. 3. [Sss/SHS]. 4. [Tertiary]. 5. [No. Formal Education]

B. Farm Characteristics

7. Farm size……………..
8. Name the type of tomato varieties grown: **(tick)…**1. [Navorongo], 2. [Power], 3. [Derma], 4. [Roma], 5. [Asente], 6. [Wosowosom], 7.[Pentomech], 8. [Fadiabegye], 9. [Ada-cocoa] others……………
9. List all the type of pesticide used in pest control on tomato cultivation…………………………………..
10. Do you use combination of pesticides some times to control insects and diseases on your tomatoes? **(tick)** 1. [Yes] 2. [No] and Why?.....................................
11. How many types of pesticides do you mix at a time? (tick) 1. [One] 2. [Three] 3. [Two] 4. [Four] and Others………………
12. How is the mixing done?(**Tick**) 1. [Two different types of insecticides] 2. [Two different types of fungicides] 3.[insecticide and fungicides] 4.[two different types of fungicide and

one type of insecticide] 5. [two different types of insecticide and one type of fungicide] 6. Others……………….

13. Which pesticide types do you mix? Please mention the names……………………………
14. Reason for mixing…………………………………..……………………………
15. The Spraying of one type of pesticide at a time and the use of combinations, which is more effective?..
16. Reason for spraying……………………………………………………...............
17. What do you use to measure the quantity of pesticides you pour in to the spraying machine...
18. Name the insecticides and fungicides you use during the nursery stage…..
19. Name the insecticides and fungicides you spray during the growth stage of the tomato………
20. Name the insecticides and fungicides you use during the flowering stage……………
21. Name the insecticides and fungicides you use during fruiting……
22. Name the insecticide and fungicides which you use during the harvesting periods………Why?……
23. Do you read the label on the chemicals container before using the chemicals? **(tick**) 1. [Yes] 2. [No] Why?.......
24. What type of insect pest do you control?**(tick)** 1. [Leaf worms] 2. [Fruit borer] 3. [whitefly] 4. [Termites] 5. [Aphides] 6. [Nematodes/Root knot] others………
25. What type of disease do you spray against?**(tick)** 1.[wilt] 2.[leaf spot] 3.[leaf curl] 4. [Fruit rot] 5. [Blossom-end rot] 6. Others………………
26. What quantity of insecticides do you use per tank?.................
27. What quantity of fungicides do you use……………......................
28. Name the type of sprayers you use in spraying your crops? **(tick)**1. [Motorized/ motor blow] 2. [knapsack sprayer] 3. Others……………………….
29. What are your reasons for choosing or selecting the chemicals you use? **(tick)** 1).[Price is moderate] 2.[Effective control] 3. [Easily Available] 4. [Improve fruit colour] 5. [Keeps fruit firm] others......................
30. How do you know you need toapply chemicals on your tomatoes?........................
31. What time of the day do you spray your crops? (Tick) 1. [Morning] 2.[Afternoon] 3.[Evening] 4.[others]…………and Why?.....................................
32. How efficient are the pesticides you use?

a. Very effective (80-90%)……
b. Moderate (60-70 %)…………
c. Poor (below 40%)……………

33. How many fillings or tanks do you use to spray your farm?......................
34. How long do you wait after spraying before harvesting?................and why?................
35. Where do you buy your pesticide? [(tick) 1.[from Friends] 2.[in the markets on table tops] 3.[from vehicles that comes on market days] 4.[from dealers shop] 5. [others]……
36. Do you wear protective cloths when spraying?(**Tick)** the ones used 1. [Nose mask] 2. [boots] 3.[goggles or spectacles] 4.[short sleeves] 5.[long sleeves]6.[shorts] 7.[trousers] others……the once you do not use why?.........
37. What are some of the effect experience after spraying?......................
38. How do you sale your tomato ?.(**Tick**} 1.[Retailers]2. [wholesalers] 3. [On the farm]4. [in the market] others…….Why?..........
39. Do you receive any complains from the buyers with regards to the tomato they buy from you?.(**Tick**)..1. [Yes] 2. [No] if yes what are the complains……;.
40. Do you eat the fruits from your farm (**Tick**) 1. [yes] 2.[No] if No why?...........

Appendix 2b: Questionnaire for Tomatoes Sellers

This questionnaire is aimed at assessing the types of pesticides tomatoes farmers in the Fanteakwa Districts in the Eastern Region. Respondents should be confident and assured that their identity would be kept confidential. Thank you for your cooperation.

Socio- Economic Characteristics

Name of Enumerator…………………Name of District……………………

A. Respondents Characteristics

1. Name of Respondent……………
2. Gender. 1. Male (…………) 2. Female (………..)
3. Name of Community……………
4. For how long have you been in this business?...
5. Where do you go to sell the tomatoes you buy from the farmers?................................
6. Why do you choose to buy from here?..
7. Where do you buy from? (Tick) 1. [Farm gate or on the farm] 2. [in the market] 3. Others……Why?…………………
8. Do you support any of the farmers with any form of credit? 9 Tick) 1.[yes] 2. [No] if yes, in what form do you give the credit? (**TICK**) 1.[cash]2.[Farming in puts] 3. Specify others……………………..
9. Is there any problem with the tomatoes you buy from the farmers? If yes Explain..
10. Are you aware of chemicals used by farmers? (TICK) 1.[Yes] 2. [No] and what are your impression the chemicals used by farmers……………………………
11. Are you satisfied with the quality of tomatoes you buy from the farmers? (TICK) 1. [Yes] 2. [No]Why?.......................
12. What are the comments that your customers make in regards to the quality of tomatoes you sell to them? …………………………………………………
13. What do you think the farmers can still do to improve upon the quality of the tomatoes they sale to you?……………………………………

Appendix 2c: Questionnaire for Agro Pesticide Sellers

This questionnaire is aimed at assessing the types of pesticides tomatoes farmers in the Fanteakwa Districts in the Eastern Region. Respondents should be confident and assured that their identity would be kept confidential. Thank you for your cooperation.

Socio- Economic Characteristics

Name of Enumerator…………………Name of District……………………

A. Respondents Characteristics

1. Name of Respondent……………
2. Gender. 1. Male (…………) 2. Female (………..)
3. Name of agro input shop………
4. Location of agro input shop………
5. Educational background of shop attendant.(tick) 1 [Primary]. 2. [Jss/ Middle]. 3. [Sss/SHS]. 4. [Tertiary]. 5. [No. Formal Education]
6. List any special training attended by shop attendants…………
7. Is the shop registered?, if yes if which organization?..................
8. What type of chemicals do you sell to farmers? Tick and give examples
9. 1.[contact insecticides] E.g……;……………………………………………
10. 2. [Systemic insecticides] E.g…………………………………………………..
11. [Contact Fungicides] E.g………………………………………………………
12. Systemic fungicides]E.g………………………………………………………
13. Are farmers able to explain their problems clearly to your satisfaction? For help?.
14. If No, Explain…………………………………………………………………….
15. Are you able to explain the use of chemicals to farmers? (TICK) 1. [yes]2. [No]………………
16. Why?..........................
17. What do you suggest must be done for you to be able to assist the farmer?......................
18. Do you think farmers always buy their pesticides from the right sources or recognized shops? (TICK) 1.[Yes] 2.[No] if no, where do you think they also buy from?................Why?..

19. What are some of the problems you think the farmers will face from buying from those sources?..

20. What do you suggest must be done?...

Appendix 2d: Questionnaire for Tomatoes Consumers

This questionnaire is aimed at assessing the types of pesticides tomatoes farmers in the Fanteakwa Districts in the Eastern Region. Respondents should be confident and assured that their identity would be kept confidential. Thank you for your cooperation.

Socio- Economic Characteristics

Name of Enumerator…………………Name of District……………………

A. Respondents Characteristics

1. Age……….
2. Gender [……]
3. Location [……………….]
4. Do you use tomato?..Yes [ ] No. [ ]
5. What are some of the kind uses soup [ ] stew [ ] Grind and eaten fresh[ ]
6. What are some of the qualities you look out for when buying tomato…………………………..,………………………………………………………
7. What stage of ripeness do you prefer fully ripe[ ] partially ripe [ ] soft [ ]
8. Comment on the appearance of the tomatoes you buy…………………………………...
9. Have you ever experience any form of complication after eaten fresh tomato? State them
   ……………………………………………………………………………………………
   ……………………………………………………………………………………………
   ………………………………………………………………………………