MALATHION RESIDUES ON SELECTED FRESH VEGETABLES PRODUCED BY SMALL SCALE FARMERS OF CHINSALI DISTRICT, MUCHINGA PROVINCE, ZAMBIA

by

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DECLARATION

I **Bernard Mwansa** hereby certify that this dissertation represents my own work and all sources quoted herein have been acknowledged by means of complete referencing. Further, I declare that this Dissertation has not been previously submitted for a Degree, Diploma or other qualifications of any university. It has been prepared in accordance with the guidelines for Master's degree Dissertation of the University of Zambia.

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CERTIFICATE OF APPROVAL

The University of Zambia approves this dissertation by **Bernard Mwansa** in partial fulfilment of the requirements for the award of the degree of master of public health in Environmental Health programme.

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ABSTRACT

Vegetables are a vital source of fiber and vitamins which also support disease prevention. To increase the efficiency of vegetable production; Farmers use chemical pesticides so that losses of vegetable growth to pests are minimized. However, these pesticides are poisons that can adversely affect human health if residue quantities are beyond permissible limits. Therefore, a study was conducted with the aim of assessing the presence of Malathion residues on selected fresh vegetables sold in markets of Chinsali district.

A cross sectional study involving forty (40) small scale farmers from three Agriculture camps of Chinsali district were randomly selected and a structured questionnaire was administered. Forty vegetable samples were collected from the same farmers of which 19 were rape and 21 were tomato samples that were taken to laboratory with the aim of determining the presence and quantity of Malathion pesticide residues. Chemically analysis was conducted on collected vegetable samples using gas chromatograph with selective Electron Capture Detector (ECD).

A total of 40 vegetable samples were collected and sent for analysis at Zambia bureau of standards in Lusaka. The 40 samples consisted of 21 tomato and 19 rape samples. Analysis showed that 31 (78%) of the 40 samples had Malathion. Residue contamination ranging from 0.65mg/kg to 19.34mg/kg. Twenty one (21) fresh tomato samples analyzed, 19 (90%) were found to be contaminated with malathion of which 9 (43%) were heavily contaminated above recommended maximum residue limit value of 8mg/kg according to the Food and Drugs Act Chapter 303 of the Laws of Zambia. Out of the 19 vegetable samples of rape, 12 (63%) were found to be contaminated with malathion residues of which 3 (16%) were heavily contaminated above recommended threshold limit value of 8mg/kg Food and Drugs Act Chapter 303 of the Laws of Zambia.

Studies showed that gender, level of education, location of the farm (Agriculture camp), farm size, source of pesticides, farmers source of information, pesticide information source, vegetable type, able to read label instructions were not significantly associated with malathion residue contamination of tomatoes and rape, (p value > 0.05). However, age of a farmer was significantly associated with Malathion contamination of tomatoes and rape. Farmers between the age 41 and 50 years old were 1.5 more likely to produce Malathion residue contaminated vegetables (P 0.0001, CI 1.67-3.332) while farmers above 51 years of age were 40% less likely to produce malathion contaminated vegetables than younger farmers (P 0.001, CI -1.37, -0.43). The study also showed that farmers who had poor knowledge of pesticide environmental effects were 60% less likely to have their vegetables contaminated with pesticides.

Vegetables produced in Chinsali by small scale farmers had Malathion pesticide residues above maximum residue limits. The main factors associated to pesticide residue concentration on fresh vegetables include age and inadequate knowledge on environmental effects of pesticides.

Keywords: Malathion, Maximum Residue Limit (MRL), pesticide residues

DEDICATION

I dedicate this work to Almighty God the creator of Heaven and this earth through his son Jesus Christ the redeemer for allowing me complete this course. It was the period of major setbacks in my private life but the Lord guided and strengthened me all the way and made me reach to this end. Much gratitude goes to all my sisters and brothers that were encouraging me in prayer.

This dedication cannot be complete without saying thanks to my Children especially my last born daughter Blessings and her Brother Theophilus for the tolerance they gave to me during the hard times. God bless them all.

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I extend sincere gratitude to the data collectors and small scale farmers that responded to the survey questionnaires and interviews. I also thank my colleagues in the study team nicknamed "Pipo of my Colour", and the staff at Muchinga Provincial Medical Office for the support and encouragement they used to render to me. I thank the Muchinga Provincial Administration for allowing me undertake the study within its jurisdiction. It is my sincere hope that the results and findings in this report will help inform the responsible stakeholders in vegetable production such as the department of Agriculture, Zambia Environmental management agency and the Ministry of Health to refocusing of programmes on pesticide management on food production in order to reduce incidences of non-communicable diseases that may have been associated to consumption of fresh vegetables produced by small scale farmers.

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ABBREVIATIONS AND ACRONYMS

CDC	Centre for Disease Control and Prevention
CSO	Central Statistical Office
DDE	Dichlorodiphenyl dichloroethylene
DDT	Dichlorodiphenyl trichloroethane
ECD	Electron Capture Detector
EMA	Environmental Management Act
ERES	Excellence in Research Ethics and Science
FAO	Food and Agriculture Organization
FTC	Farmers Training Centre
GC	Gas Chromatography
GCMS	Gas Chromatography Mass Spectrometer
HPLC	High Performance Liquid Chromatography
IDSR	Integrated Disease Surveillance and Response
IRB	Institute of Research Board
MAFF	Ministry of Agriculture Food and Fisheries
MRL	Maximum Residue Limit
N_2	Nitrogen
NHSP	National Health Strategic Plan
PCDD	Polychlorinated dibenzo-*p*-dioxins
PCDF	Polychlorinated dibenzofurans
POPs	Persisted Organic Pollutants
SOPs	Standard Operating Procedures
STATA	Data Analysis and Statistical Software
UN	United Nations
UNEP	United Nations Environment Programme
UNZA	University of Zambia
USA	United States of America
WHO	World Health Organisation
ZEMA	Zambia Environmental Management Agency

CHAPTER ONE
INTRODUCTION

1.1 Background Information

Globally, food poisoning arising from consumption of chemically contaminated vegetables has been noted in both acute and long term exposure effects (Clistos & Illias, 2011). The World Health Organization (WHO) and United Nations report indicated that pesticide poisoning rates stands at 2 to 3 persons per minute (WHO, 2014). An approximate of 20,000 people die each year due to pesticide poisoning of which the most affected are in developing countries (Nepal *et al,* 2010).

The worldwide use of pesticides is about two million tonnes per year of which 25% is consumed in USA, 45% in Europe, 3.75% India and 27% in the rest of the World. Out of the total consumed pesticides, 29.5% are insecticides, 47.5% are herbicides, 17.5 fungicides and less than 5.5% others (De, *et al,* 2014). Vegetables form part of normal human diet and aims at maintaining human nutritive sufficiency through the provision of energy, protein, vitamins, minerals and prevent diseases (NFNC Zambia, 2011; Nicholas and Hilmi, 2009; Oguntibeju *et al*, 2013; Wang *et al,* 2014; *He, et al, 2007).* For the poor African countries like Zambia, vegetables act as part of the main relish on everyday menu together with cereals (Hichaambwa *et al,* 2009; Dong and Lin, 2009). Pesticides are used in vegetable production to mitigate losses due to fungi, worms and insects, and diseases of significance importance in agriculture (Finnish Institute 2014). However; the use of chemicals in vegetable production is a risk of food poisoning when its application is not taken with great care (Gupta, 2004).

There are four main classes of chemical pesticides used in vegetable production. These include the organochlorines, organophosphates, carbamates and Pyrethroid. All these pesticides are found in various formulations and with a variety of uses. For the purpose of this study, the class of chemical to be studied is the organophosphates in particular Malathion, chemically referred to as diethyl (dimethoxy phosphinothioyl) thiobutanedioate (Deltamethrin, 2001). Malathion is an organophosphate with a chemical formula $C_{10}H_{19}O_6PS_2$. It is among the widely used pesticides among vegetable farmers in Bangladesh. In agriculture, Malathion targeted pests include ants, aphid's apple mealybugs, army worms, bag worms, maggots and many more (Hazard substance databank, 2008)

This pesticide is also widely used among local farmers in Chinsali in the production of fresh vegetables for human consumption.

Malathion is known with several names according to manufacturers and countries of origin. These include maldison, malathon, mercaptothion, mercaptotion, carbofos (WHO, 2003). Trade names for products containing Malathion as an active ingredient include Celthion, Cythion, Dielathion, Karbofos, Maltox, El 4049, Emmaton, Fyfanon and Exathion among many others.

Malathion is a pesticide that is used both in Public health and agriculture purposes. It is a colorless to amber liquid with a garlic- or skunk-like odor that is used to control a wide range of insects that infest vegetable plants (Newhart, 2006).

It is a non-systemic wide spectrum insecticide but a nerve poison and works essentially by attacking the nervous system by inhibiting enzyme acetylcholinesterase (AChE). AChE, acetylcholine, which is essential in transmitting impulses between nerves (EPA, 2006). This pesticide is an organophosphate classified (III) as slightly hazardous and is associated with acute and long-term health effects if not properly applied (WHO, 2010).

In Agriculture, Malathion is suited for the control of sucking and chewing insects and mites on fruits and vegetables (Gallo *et al*, 1991).

Malathion is rapidly and effectively absorbed by practically all routes including the gastrointestinal tract, skin, mucous membranes, and lungs. It is classified among the most toxic chemicals by the World Health. However, it is among the pesticides permitted to be used in food production (Tchounwou *et al*, 2015). Farmers that use Malathion must strictly observe the withholding time (lead time) before the sprayed or treated vegetables are harvested for human consumption. This is to allow for the chemical to breakdown to such levels that can be less toxic to consumers of these vegetables. The maximum amount of Malathion residue allowed by the FDA and EPA on crops used as food is 8 ppm of Malathion with a minimum holding time of six days before harvesting. Once Malathion is introduced into the environment, usually from spraying on crops, droplets of Malathion in the air fall on soil, plants, water, or man-made surfaces but is usually broken down into other chemical compounds (Extension Toxicology Network, 1996; Gallo et al, 1991).

Apart from acute health effects, Malathion is associated with long-term human health hazards such as cancer, kidney ailments and reproductive consequences. These are associated with inappropriate application of pesticides in general that exposes humans to Malathion (Padmajani, et *al*, 2014). The World Health Organization had realized the importance of controlling the use of pesticides in food production and called for its member countries, parties and regional bodies to control the production, importation, sale and utilization of agricultural pesticides (EPA, 2009). A body such as the Codex Alimentarius Commission is mandated to protect the health of consumers and ensure fair practices in international food trade. Among other food standards, the Codex Alimentarius commission has drawn the code of practice, guidelines, and other recommendations relating to vegetable production, quality, and chemical safety in which Maximum Residue Limits (MRL) of pesticide residues are stipulated (WHO/FAO, 2014). In order to uphold the international commitments, the Zambia Environmental Management Agency (ZEMA) was given a mandate to control among other things the production, importation, sale, use and disposal of pesticides (EMA No. 12 of 2011). Hence pesticide use in vegetable production among small scale farmers is regulated by the Act.

The study intends to focus on determining the presence and assessing the association of Malathion residues on selected fresh vegetables produced by farmers of Chinsali district.

1.2 Statement of the Problem

Prevalence of pesticide poisoning is higher in developing countries where most farmers have no formal training in vegetable production. Farmers mostly learn vegetable production from friends and rely heavily on pesticides in the control of pests though having very little knowledge on pesticide management (Yeboah, 2013). In Zambia, a study on dichlovos pesticide residues in fresh vegetables in Lusaka revealed that 89.5% of vegetables contain dichlovos pesticide residues with 63.15% containing pesticide residues above MRL of 1mg/kg (Sinyangwe, et al, 2016).

In Muchinga Province and Chinsali in particular food poisoning due to pesticide residues in fresh vegetables has been a source of concern. Eighty nine suspected cases of acute chemical food poisoning with five deaths were reported in 2015 in Muchinga province and Chinsali recorded 51 cases. (IDSR, 2015). Clinical diagnosis of acute health effects (poisoning) from districts have associated cases with consumption of vegetables sprayed with pesticides. Case Histories among patients revealed that suspected victims were eating vegetables that could have been sprayed with pesticides. It could be envisaged that some more unreported single cases were happening in communities due to low exposure dose, gravity of immediate health effects, poverty, education, distance to health facilities, low diagnostic capacities and number of people affected (London & Bailie, 2001; Halwiindi *et al*, 2013).

Acute health effects ~~being~~ experienced from vegetable consumption may be a precursor to long term health effects that are difficult to notice and associate. This study is therefore aimed at investigating the presence of Malathion residues on rape and tomato fresh vegetables and determine concentration levels if any.

Muchinga Province has a total of seven districts and five districts recorded acute cases of food poisoning suspected to have been arisen from chemically contaminated fresh garden vegetables. The province recorded eighty nine (89) cases and five deaths and the highest number of cases were from Chinsali district with two episodes of chemical poisoning outbreaks with an additional total of 51 cases (IDSR, 2015). These were mere suspicions as no laboratory analysis confirmed the claims however, such reports may be a precursor to many long-term health effects such as mutagenesis, Teratogenicity and cancers that may arise as a result of high concentration of pesticide residues in fresh vegetables.

1.3 Justification of the Study

Pesticide residues have potential to cause short-term and long term health effects in humans if farmers do not follow manufacturer's instructions. Health authorities and the public have implicated vegetables produced by small scale farmers supplied to Chinsali markets (rape, Cabbage, spinach, Chinese cabbage, tomatoes and mustard) as the sources of short term chemical food poisoning in Chinsali District. Clinically, the health workers have attributed this poisoning to pesticides used in vegetable growing such as the Organophosphates, Organochlorines and

Pyrethroid (IDSR Reports, 2015). Unless the claim is false, there should be mismanagement of vegetable pesticides in vegetable production and may be contributing to both acute and long term health effects seen in health facilities. In Zambia, and Chinsali in particular, the researcher had not come across to any studies that have been conducted on Malathion residues in fresh vegetables and yet the pesticide is classified as among the class III (a slightly hazardous) Pesticides by EPA, FDA and WHO. (WHO, 2010). No studies that we came across that was conducted in Zambia which was assessing the Malathion residues in fresh vegetables and yet the pesticide is widely used among the small scale farmers in Vegetable production.

The study will try to explore factors that might have led to presence of Malathion residues in fresh vegetables in particular rape and tomatoes if any so that correct assessment of potential factors associated with Malathion residues in fresh vegetables are determined. With the findings that will be obtained, necessary recommendations shall be made to all stakeholders such as the department of Agriculture that might help to reduce the occurrence of vegetable chemical food poisoning in the community. This will assist government entities such the Ministry of Agriculture, ZEMA and Health department in devising mechanisms to prevent such occurrences and guarantee food safety among vegetable consumers. The study will also build on to the body of knowledge on presence of Malathion residues in fresh vegetables.

1.4 Main Objectives

To assess the presence and factors associated with Malathion residues in fresh vegetables produced by small scale farmers of Chinsali district.

1.5 Specific objectives

1. To determine the presence and levels of malathion ~~pesticide~~ residues on fresh vegetables produced by small scale farmers of Chinsali district
2. To ascertain whether Malathion residue concentration levels on vegetables produced by small scale farmers in Chinsali district comply with the legal requirements
3. To identify factors associated with levels of malathion residues in fresh vegetables ~~if any~~ produced by small scale farmers of Chinsali district

1.6 Research Questions

1. Do vegetables produced by small scale farmers in Chinsali contain Malathion residues at time of harvesting and if so are these levels within the Maximum Residual limit?

2. What factors contribute to presence of Malathion residues above maximum residue limits in Fresh vegetables produced by small scale farmers of Chinsali district?

1.7 Operational Definitions

The most common key words in this study include:

Pesticide residues any specified substance in food, agricultural commodities, or animal feed resulting from the use of a pesticide. The term includes any derivatives of a pesticide, such as conversion products, metabolites, reaction products, and impurities that are considered to be of toxicological significance.

Maximum Residue Limit (MRL) the maximum concentration of a residue that is legally permitted or recognized as acceptable in or on a food or agricultural commodity or animal feedstuff It is expressed in milligrams per kilogram (mg/kg).

Malathion: An organophosphate pesticide used both in agricultural and residential settings. It interferes with the nervous system by blocking an enzyme that normally acts as an off switch by ending the signal. Without the enzyme, the nerve keeps firing and eventually the nervous system fails.

Holding time (Waiting time) is sometimes referred to as waiting period and it signifies the time between harvest and last spray of pesticide to vegetables (Baig, S.A. 2009).

CHAPTER TWO

LITERATURE REVIEW

2.1. Overview

Generally, the increase in fresh fruit and vegetable production worldwide are as a result of increased technology such as mechanization and use of chemical pesticides that play an important role in reducing production losses (Sheikh et al, 2011). Initially, little attention was given to health effects associated with agricultural pesticides until the food poisoning of 1958 in India where 100 people died after consuming flour that was contaminated with parathion (Gupta, 2004). The Joint FAO/WHO quarterly report, on World Population Pyramid on pesticide exposures, single and short term exposures accounts to 3,000,000 people with 220,000 deaths annually. Long term low exposure health effects (cardiovascular) of 735,000 with long term exposure chronic effects (cancer) of 37,000 cases were reported each year (Jeyaratnam, 1990). An estimate of more than 200,000 people in rural regions of the developing countries were dying of pesticide poisoning annually among the hospitalized cases (Eddleston *et al,* 2008).

According to Mayank and Ajay (2007), 45% of world's crop is destroyed by plant pests and diseases. In most countries, fresh vegetable production is done by small scale farmers and households through backyard gardening. Since small pieces of land are cultivated, increase vegetable production hinges on reducing production loss resulting in increase in the use of chemical pesticides Mayank et al,2007.

2.2 Factors associated with pesticide Residues in Fresh vegetables

According to Gupta, 2004, farmers heavily spray pesticides to vegetables to the time of harvest and transport to markets without considering waiting period. Farag *et al*, 2011 also added that the causes of pesticide residues in fresh vegetables was the misapplication and use of unauthorized pesticides during vegetable production. These acts create very significant potential for pesticide residues causing negative health effects on vegetable consumers. On the other hand, consumers purchasing decision of vegetables most often depends on physical appearance such as being fresh through visual appearance and think those vegetables are safe (Acheampong., et al., 2012; Penau *et al*., 2006 and Sakagami *et al*, 2006 and yet such appetizing appearance is often a result of pesticides that inhibit pest and fungal infestations.

2.2.1 Factors Associated with Malathion Residues in Fresh vegetables.

Every infant born today carries a chemical body burden passed from mother to child during pregnancy. This burden will grow throughout a lifetime due to exposure to pesticides and other chemicals in our food, air, water and everyday products (Pesticide Action Network (2017). Among the 44 chemicals that are being investigated by CDC Malathion is among the pesticides that is prioritized because of its abundant use both in Agriculture and public health with the corresponding long-term and short term health effects (Centers for Disease Control and Prevention, 2009). It is a widely preferred pesticide because it is wide spectrum and does not persist in the environment. It is among the widely used pesticides among vegetable farmers in Bangladesh and accounts to about 30 million pounds and is used annually in the US and like any other pesticide in it class, it is regulated (United States Environmental Protection Agency, 2008

Malathion is an organophosphate with a chemical formular $C_{10}H_{19}O_6PS_{2.}$ It is among the widely used pesticides among vegetable farmers in Bangladesh. In agriculture, Malathion targeted pests include ants, aphid's apple mealybugs, army worms, bag worms, maggots and many more (Hazard substance databank, 2008 The no observable effect level of Malathion in humans stands at 0.34mg/kg, a yardstick that cannot produce any cholinergic signs (Bonzen and Jones, 1992; Murphy, 1986). The control of Mediterranean fruit fly in California made that state to introduce a new ACT on food safety in 1989. This was as a result of dietary acute and chronic exposures to malathion Pesticide application in vegetable fields not only affects the farmers' health but also threat to the global human health. (Miah, 2014).

2.2.2. Inadequate knowledge on pesticide management

Pesticides are poisons to both pests and humans hence, their handling and use require adequate knowledge among those involved in their applications. According to Owombo, *et al*, 2014, most of the small scale farmers that were handling pesticides in cocoa production in Nigeria had low education. They were failing to interpret the manufacturers' instructions on pesticide labels and booklets. Correct application of pesticide was increasing enhanced with the corresponding increase of visits by the Agriculture extension workers that were helping farmers understand the instructions on pesticide labels. This was similar was with the findings among potato farmers in Uganda (Okonya and Kroschel, 2015)**.** The non-understanding of labels on pesticide packaging Pesticide among vegetable farmers in Sri Lanka also led to farmers using wrong pesticides in vegetable production. It was found that (5%) were using non permitted pesticides in vegetable production. 34% were using restricted pesticides. 47% of these farmers were using organophosphates as they were cheap and able to give quick results. Farmers were not considering the toxic nature and any damage that these pesticides can cause to the environment (Padmajani et al, 2014). This scenario entails that farmers are very much concerned with reducing the production costs and minimizing any possible loss without considering effects of pesticides to the environment.

2.2.3 Farmer attitude and behaviours

In certain circumstances, lack of appropriate the application tools and equipment pose a great challenge because vegetable farmers do not have basic tools and equipment for correct dose application as prescribed by the manufacturers. However, Elodie, et al, 2010, demonstrated that it is not only small scale farming where adequate knowledge and lack of better equipment and tools for application of agriculture pesticides poor attitude has also a role to play as even big firms with all the necessary tools and equipment do not pay much attention to chemical safety of fresh vegetables passed to consumers and retailers. The same study also revealed that larger firms though having knowledge on pesticide effects were the most weak in adhering to Chemical safety efforts as compared to medium and small vegetable production industries. These indicate although lack of appropriate tools and equipment can be attributed to inappropriate of pesticide application, poor farming attitudes and behaviours are factors that contributes to increased pesticide residues in fresh vegetables.

2.2.4. Poor Adherence to Waiting Time

Waiting time in relation to vegetable production relates to scheduled times of pesticide application to plant or time between harvest and last spray. According to Yeboah (2013), waiting time between pesticide sprays on vegetables was also not being observed by vegetable farmers at Dzorwulu in Accra as stipulated on labels. Pesticide application interval was dictated by pest infestation unlike the predetermined pesticide spray calendar by the manufactures. Similar findings were obtained by Shrestha, et al, 2010; in India where farmers were applying pesticides up to four times more than recommended by the manufacturer. According to the study conducted by Nettra Bhatta, (2014), for such vegetables that require frequent harvesting, waiting time was not adhered to even if farmers were knowledgeable about that. Harvesting period was driven by the economic value of the crop harvested even if hard pesticides had been applied that require a considerable waiting time. On plant surfaces, the half-life for Malathion ranges from less than one day to about a week (Latifah, *et al*, 2011).

2.3 Health Effects Associated with Pesticide Residues

Pesticides are usually made as chemical compounds and act on human health in three forms; as an Independent chemical within that compound, through dose addition and through interaction that may result from combined exposures with two or more compounds (Allan, *et al* 2008). The combined effects of two or more chemicals is either greater (synergistic, potentiating, supra-additive) or less (antagonistic, inhibitive, sub-additive, infra additive) than that predicted on the basis of dose-addition or response-addition. Non adherence to waiting time reduces chemical break down creating very high significant potential for pesticide residues to cause either long term or short term negative health effects on vegetable consumers (Gupta et al, (2004; Centre for Eco genetics and Environmental Health, 2013).

The most at risk due to exposure to pesticides are the fetuses, infants, growing children, lactating mothers and women of Child bearing age. The most common exposure to pesticides is by eating them or through the consumption of foods that contain pesticide residues. In the study on Belgium population on exposure to pesticide residues in fresh fruits and vegetables, high pesticide exposure values were observed (Claeys et al, 2008). Long-term health effects were observed in other several studies. For example, Aniline, a carcinogenic aromatic compound was found in fresh vegetable fiber at a dose of 0.0002 to 0.0016 milligrams /litre in a study on men from a fertility clinic on Semen quality after vegetable and fruit intake with pesticide residues. Findings revealed that consumption of fruits and vegetables with high levels of pesticide residues was associated with a lower total sperm count and a lower percentage of morphologically normal sperm among men presenting to a fertility clinic as a result of exposure to DDT and its metabolites (Chiu,. *et al.*, 2015; Bempah, *et al,2013*).

2.4 Health Effects Associated with Malathion

Malathion is an organophosphate with a chemical formula $C_{10}H_{19}O_6PS_2$. It is among the widely used pesticides among vegetable farmers in Bangladesh. It is a widely preferred pesticide because it is a wide spectrum pesticide and does not persist in the environment. It accounts to about 30 million pounds and is used annually in the US and like any other pesticide in class III it is regulated (U.S.EPA, 2008). In agriculture, Malathion targeted pests include ants, aphid's apple mealybugs, army worms, bag worms, maggots and many more (Hazard substance databank, 2008). The no observable effect level of Malathion in humans stands at 0.34mg/kg, a yardstick that cannot produce any cholinergic signs (Bonzen and Jones, 1992; Murphy, 1986). The control of Mediterranean fruit fly in California made that state to introduce a new ACT on food safety in 1989. This was as a result of dietary acute and chronic exposures to Malathion Pesticide application in vegetable fields not only affects the farmers' health but also threat to the global human health. **(**Miah, et al, 2014). In 1967 – 1968, 35 cases of Malathion poisoning reported in Indore where 5 were dead due to myocardium damages (Gupta, 2004). The LD50 value (LD50 2100 mg/ kg) for Malathion is depends on its impurities where iso-malathion is the major toxic component.

2.5. Legal Framework

In order to protect human health and the Environment, in May 2001, UNEP called for an international conference in Switzerland commonly referred to as the Stockholm Convention which aimed at focusing on Persistent Organic Pollutants (POPs) that include pesticides and industrial chemicals such as hexachlorobenzene and polychlorinated biphenyls, for the purpose of reducing their production and use. The other intention of UNEP was to develop a methodology that allows developing and developed countries to make estimates of PCDD/PCDF releases into the environment along all vectors so that countries and parties could create inventories that could serve as starting points for interventions to reduce or eliminate sources of PCDD/PCDF through the application of specific techniques and practices that can best reduce environmental contamination / pollution (Stockholm Convention, 2001). The recommendations of this convention well adopted by major parties including Zambia.

The Zambia Environmental Management Agency (ZEMA) through Act No. 12 of 2011 has been mandated to control the manufacture, importation and transportation with the responsibilities of monitoring and issuance of licenses of pesticides in Zambia, Section 65 and 66. The Food and Drugs Act 303 has not favoured the use of pesticides in foods but permitted only under such precautions and restrictions that will not contaminate the food as per section 418). The Food and Drugs Regulations of 2001 stipulates the use of pesticides in Zambia on vegetables such as Tomato and rape with maximum residue concentration limit of Malathion is 8ppm (8mg/kg). This was adopted from the Environmental Protection Agency and the Food and Drugs Administration (FDA) of the United States of America. The joint committee of the World Health Organization with Food and Agriculture Organization had set the standard of malathion residues in fresh fruits and vegetables at 2.0mg/kg. The Codex Alimentarius Commission has prescribed the MRL of 0.5mg/kg for processed Rape and tomato which had been the recommendation also by the joint FAO/WHO Commission of 1989 and 2000.

2.6 Summary

The above literature entails that fruit and vegetable consumption reduces human chances of ill health but the pesticide residues that are at times found in these vegetables can be detrimental to human health. Inadequate knowledge on pesticides effects both to human and the environment. The poor adherence to withholding time and poor attitude towards pesticide management are also factors that increase pesticide residues in fresh vegetables. Like other pesticides, it was also noted that Malathion has both acute and long term health effects. Noticing the health effects associated with pesticide residues in fresh vegetables most countries and international bodies such as EPA, WHO/ FAO, Codex Alimentarius and the Food and Drugs Administration have formulated laws to regulate the use of pesticides.

CHAPTER THREE

METHODOLOGY

3.1 Study design

A cross sectional study design was employed. It was a snapshot survey to determine the prevalence and factors associated with Malathion levels on fresh vegetables, an organophosphate pesticide sprayed on fresh vegetables. Vegetable samples were collected for determination of the presence of pesticides in fresh vegetable and potential risk factors associated with presence and levels of Malathion residues were observed.

3.2 Location of the Study

The study was conducted in Chinsali district of Muchinga Province. The study area was composed of three Agricultural camps namely; Chinsali Central, Chibesa and Farmers Training Centre (FTC) with ten villages located within these three agriculture camps catchment areas (See appendix 4). The three agricultural camps were the highest producers of vegetables in Chinsali that are sold at Chinsali Main and Location Markets where the purchased vegetables were destined for sale.

3.3 Target Population

All small scale vegetable farmers living and farming within Chinsali Central, Chibesa and Farmers Training Centre Agricultural Camps that had rape (B*rassica napus*) and/or Tomato (*Solanum lycopersicum*) readily available for supply to Chinsali main and Location markets during the data collection period. Forty vegetable farmers were recruited of which 19 had rape and 21 had tomato. The studycould not recruit equal numbers of rape farmers and tomato farmers as during the time of study, most farmers opted to grow tomato due to high demand and all the rape farmers were recruited on the last sample collection day.

3.4 Sample size

Prevalence of Malathion residue in fresh vegetables in previous study was estimated as 12% (Franco, *et al*, 2007). A total of 40 samples adjusted at 10% for non-valid sample of fresh vegetables were required to detect Malathion at 80% power for a two-sided 5% level of significance using Pearson Chi-square test.

$$n = \frac{(Z_{1-\alpha}{}^{2})^{2} P (1-P)}{d^{2}}$$

Where n= required sample size, P= prevalence (%) of Malathion from previous studies, $Z1-\alpha = 1.96$, d (measure of precision) = 10%

3.5 Sampling Techniques

Samples were collected from the three Agriculture camps. Information from the department of Agriculture indicated that there were more vegetable farmers in Chinsali central and FTC Agriculture camps with very few in Chibesa Agricultural camp. Hence the agricultural camps were segmented into four areas each and samples were collected from all the four areas of each agricultural camp according to the available produce that was found harvested for sale by the small scale farmers during the sample collection day. In Chibesa Agricultural camp, vegetable growing was only in one area and samples were collected from that one area. Fresh rape (*Brassica napus*) the most common vegetable of the *brassica* family grown among small scale farmers and tomato (*Solanum lycopersicum)* is widely used during food preparation. Convenient sampling was employed since the researcherdid not anticipate the numberof farmers that were going to harvest the targeted vegetables at the sample collection day. The tomato and rape samples were purchased as lot samples of 1kg each from small scale farmers from Chinsali central, Chibesa and FTC agricultural camps catchment areas. The purpose of buying was not to let farmers incur any loss on the vegetables they were taking for sale. The sample was bought at the market selling price (K5.00) to avoid any social alarm. (See appendix 4). The samples were collected from all the farmers that were found with harvested rape and Tomato during the two sampling and data collection days. Since the number of farmers were not known, convenient sampling was used targeting every farmer in the selected areas that were found with harvested vegetables that was ready for sale during the sample collection day. Sample collection was done within a period of five weeks in order to ensure that different yields from different farmers were picked in the next sample collection. There was a three weeks interval between the first collection and the final collection. Each of the two sample collection weeks had one sample collection day that was randomly selected from the seven days of a week. The suppliers of tomato and rape to marketers were the respondents to the questionnaires that were administered in the study. A total of 40 small scale farmers selected through simple random sampling took part in the study. Each farmer contributed one sample to the study. These farmers were randomly selected within the same weekly criteria explained above.

3.6 Sample collection

Only fresh harvested rape and tomato was purchased as samples from farmers of the three agriculture camps. These vegetables were ready for sale to the marketers of Chinsali and location markets that were following farmers at their farms/gardens on each sample collection day.

A Lot sample of edible parts of rape and tomato from Small scale farmers were randomly collected from the sack or box until a bunch of 1kilogram was obtained. One kilogramme of either rape or tomato constituted one sample. This sampling criteria is according to Food and Drugs Inspection procedure manual of 2009, which states that a lot sample can be obtained at random in so many points of the consignment until a representative sample is obtained. Each sample was coded and recorded on a separate food sampling form and accompanied with a vegetable sample for laboratory analysis (Appendix 8). Rape and Tomato samples were packed in separate paper envelops, properly labeled and kept in a cooler box at the point of collection. The vegetables were later kept in a refrigerator at a chill temperature of between 4 ^{0}C to 10 ^{0}C. The cooled samples were transported to Zambia Bureau of Standards laboratory in a cold box within 48 hours from the time of collection.

3.7 Data Collection Methods and Procedure

Structured questionnaires were used to collect data on demography, socio economic and pesticide management from small scale farmers whom samples were procured.

Dependent variable: In this study, the dependent variables were the presence of Malathion residues in fresh vegetables and level of Malathion residues above or within MRL. The independent variables were factors that included the following;

- **Demography**: Age, Gender and Agriculture camp
- **Socio-economic:** farm size, level of education, level of Knowledge on vegetable farming
- **Pesticide management:** level of Knowledge on pesticide management, waiting time, ability to read label instructions, availability of label on packaging, having appropriate pesticide application and pesticide measuring tools.

Data collection for the study involved five personnel, the Principal Investigator (PI) with four Research Assistants (RA). The research assistants underwent training for one day to ensure correct data was collected and secured in order to ensure validity and security of data. The Principal Investigator (PI) was responsible for collecting and packaging of samples and on site data verification. Research Assistants were responsible for data collection through the administration of the structured questionnaire in face to face interview to rape and tomato farmers at the farm/garden, a point of production Collected data was safely kept in a lockable cabinet to ensure no unauthorized access to it.

During research forty four samples were taken to the laboratory for analysis. In Essence only forty samples were collected for analysis. The four other vegetable (two rape and two Tomato) samples. Two kilogramme of either rape or tomato was collected and later split into one kilogramme each and identified by the researchers as replica and parent sample. These replica samples were Two kilogramme of either rape or tomato was collected and later split into one kilogramme each and identified by the researchers as replica and parent sample. Two kilogramme of either rape or tomato was collected and later split into one kilogramme each and identified by the researchers as replica and parent sample. for the purpose of ascertaining uniformity in sample collection as well as quality in laboratory analysis, the samples that were replicated were labelled and paired as follows: MG/CC/TM/02 with MG/CC/TM/04, CG/FTC/RP/03 with CG/FTC/ RP/01, GV/CC/TM/01 with GV/CC/TM/03, and GV/CC/RP/02 with GV/CC/RP/03, After laboratory analysis, the results were very similar as compared to the parent samples.

3.8 Chemical extraction and Laboratory analysis

The edible part of rape and ripe tomato were the samples collected for chemical analysis. A representative fifty grams of the sample of edible parts of rape or tomato was cut into pieces and mixed with acetonitrile (repeated thrice with 50 ml) in a blender; The resultant mixture was then poured into separator funnel and shaken with 400 ml of 3:2 mixtures of *n*-hexane and dichloromethane for one hour this mixture. After shaking, the separatory funnel was left in the same position for 30 min to have distinct layers; *n*-hexane layer was then taken into round bottom flask, concentrated to dryness by rotary evaporator while leftover layer being discarded. The samples were then

Subjected to florisil column (60 cm×22 mm) packed with florisil and activated charcoal (5:1 w/w) in between two layers of anhydrous sodium sulphate. Extract was eluted with 125 mL mixture of ethyl acetate:hexane. The eluted portion was evaporated to dryness and the residues were dissolved in *n*-hexane and the volume was made up to 2 ml with *n*-hexane (HPLCgrade) Samples, thus obtained, were injected (1 μl) and analyzed for the presence of organophosphorus pesticides by Gas Chromatograph (Hewlett Packard 5890) with selective electron capture detector (ECD) that allowed the detection of contaminants (OPs) even at trace level concentrations (in the lower ppb range) from the matrix to which other detector do not respond. Samples, thus obtained, was injected (1 litre) and analyzed for the presence of Malathion by gas chromatograph (Thermofinigan Trace GCMS) with selective Electron Capture Detector (ECD) to detect contaminants (Zweig and Shama, 1984).

3.9 Data Processing and Analysis

Information from questionnaires was aggregated using tables in excel programme (Appendices 6 & 7). Later, this data was exported to STATA 13.0 software for statistical analysis.

Descriptive statistical analysis was used to summarize data using median and inter quartile range. Bivariate logistic regression analysis was used to test the strength of association and multiple logistic regression for controlling confounders and likelihood test was employed to calculate the P- values

($P < 0.05$) in order to identify the significance of independent variables against the dependent variables.

3.10 Ethical considerations

The study probably might have injured some respondents or community members psychologically for they could have been anxious to know the purpose of the study results. In view of this, Researchers were explaining the purpose of the study to all respondents.

Benefits: Small scale vegetable farmers and the public that consume the vegetables produced by the farmers had confidence in the safety of the products and the consumers were assured of safety of the produce. The study has an intention to improve interaction between the small scale farmers and Agricultural Extension Workers. The farmers will also have an opportunity to understand the importance of correct use of pesticides during vegetable production.

Anonymity The farmers were assured confidentiality of the data collected from them as no names were attached to the questionnaires. Instead, they were identified with the codes. In order to ensure acceptable morality of research, the target participants included in the study were normal persons above the age of 18 years as these are considered as adults according to Zambian Law.

Informed consent: The participants who met the criteria for this study had a right to give an informed consent before being recruited and those accepted taking part in the study were assured respect, confidentiality anonymity as participants and their names were not reflected on the questionnaires. All study participants had a choice to withdraw from the study at any time they so wished.

Authority: In order to ensure research acceptability and transparency, Authority was sought from the department of Agriculture at provincial and district levels which were later taken to the Agricultural camp extension offices. The activity was conducted within the district of Chinsali hence the District Administration Commissioner authorized the research that took place in these areas. During the execution of the study, researchers were paying courtesy calls to community leadership in the areas of study.

In order to ensure that all ethical considerations were adhered to, the proposal was presented to Excellence in Research Ethics and Science (ERES) Converge for permission and approval was obtained. The collected data or information from the respondents was securely stored in a lockable cabinet. The vegetable samples that were collected were properly coded and secured immediately after collection and these was analyzed by qualified personnel from Zambia Bureau of Standards (ZABS) laboratory. Data analysis was done in confidence in order to ensure privacy of personal information of participants in relation to laboratory results of vegetable samples.

3.11 Pilot Study

In order to validate the data collection and compilation tools, a pretesting of the data collection tools was conducted in Mpika at Mpika main market and Malashi vegetable farming area which has similar characteristics to the two markets of Chinsali and farming areas respectively. Data obtained helped to adjust the data collection and compilation tools which were found with no major changes apart from a few typing errors.

CHAPTER FOUR

FINDINGS AND INTEPRETATIONS

4.1 Determining the presence and levels of Malathion pesticide residues on fresh vegetables

The first specific objective was to determine the presence and levels of Malathion pesticide residues in fresh rape and tomato vegetables. The social demographic characteristics and pesticide management variables were analyzed during the study. The descriptive statistics of the study sample were carried out and are shown in figure 1. The study sample was characterized by a number of respondents using Malathion that was beyond the maximum permissible dose 8.0 mg/kg. (Food and Drugs Regulations,2001 of the Laws of Zambia).

4.2 Laboratory Results of Rape and Tomato samples

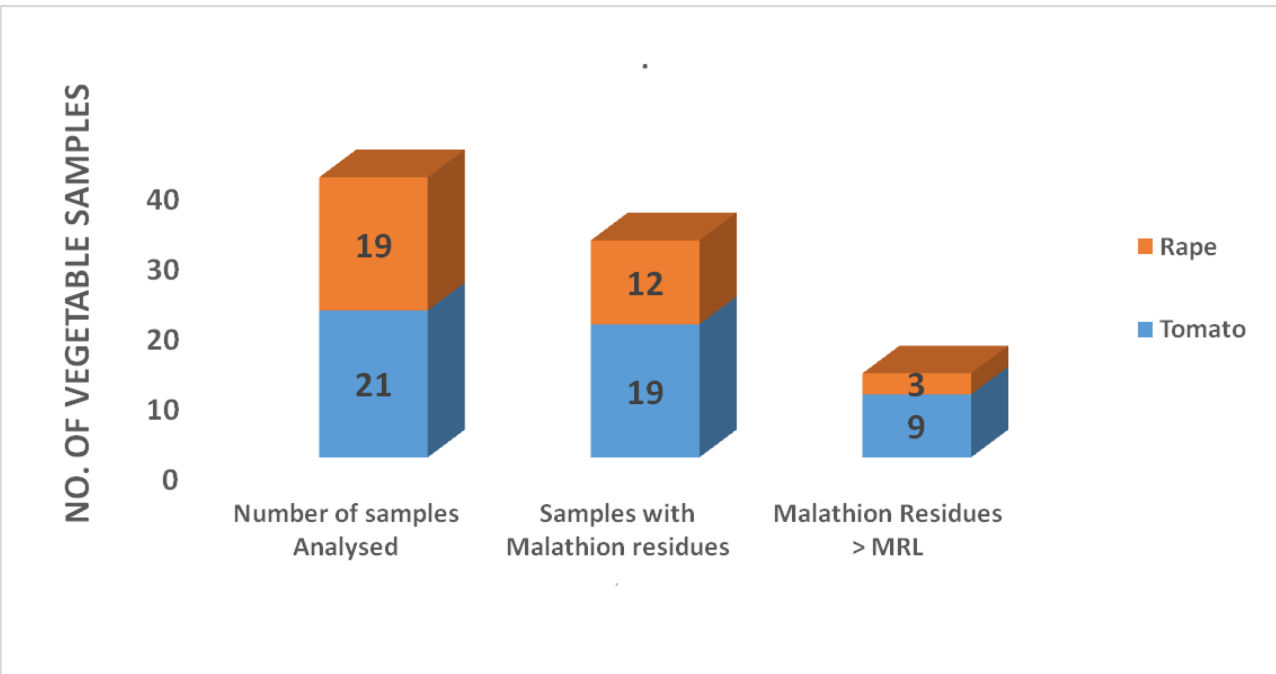

Figure 1. Laboratory Results of analyzed tomato and rape samples

Forty vegetable samples that included 19 samples of Rape and 21 samples of tomato heaps were collected and analyzed at Zambia Bureau of Standards laboratory, 31 (77.5%) samples had Malathion residues present while nine samples had no traces of Malathion residues. This indicated that most farmers were using Malathion as a chemical pesticide in vegetable production among other pesticides. The laboratory investigation also revealed that among the 31 samples that had Malathion residues, 19 (61.3%) samples analyzed were within the maximum residue limit. From the total of thirty one samples that had Malathion residues present, 19 (61.3%) were tomato samples and 12 (38.7%) were that of rape. Out of the 19 tomato samples that had Malathion present during chemical analysis, 9(47.4%) samples had Malathion residues greater than 8mg/kg the maximum residue limit prescribed in the Food and drugs Act. Also out of the 12 rape samples that were found with Malathion pesticide residues during laboratory chemical analysis, 3 (25%) of the rape samples had Malathion residues greater than 8mg/kg.

Table 1. Malathion Residue Characteristics in Vegetable Samples

Characteristic	**No. of Samples (%)**	**No. of samples with Malathion MRL(%)**	**No. of samples with malathion > MRL (%)**
Vegetable Type			
Tomato	21 (52.50)	19 (61.29)	9 (75)
Rape	19 (47.50)	12 (38.71)	3 (25)
Total	40 (100)	31(100)	12

Source: field data 2017

The study revealed that out of the 40 samples collected, 31 samples of both rape and tomato had Malathion residues and 12 samples of both rape and tomato had Malathion residues greater than 8.0 mg/kg, i.e., 3 rape samples and 9 tomato samples

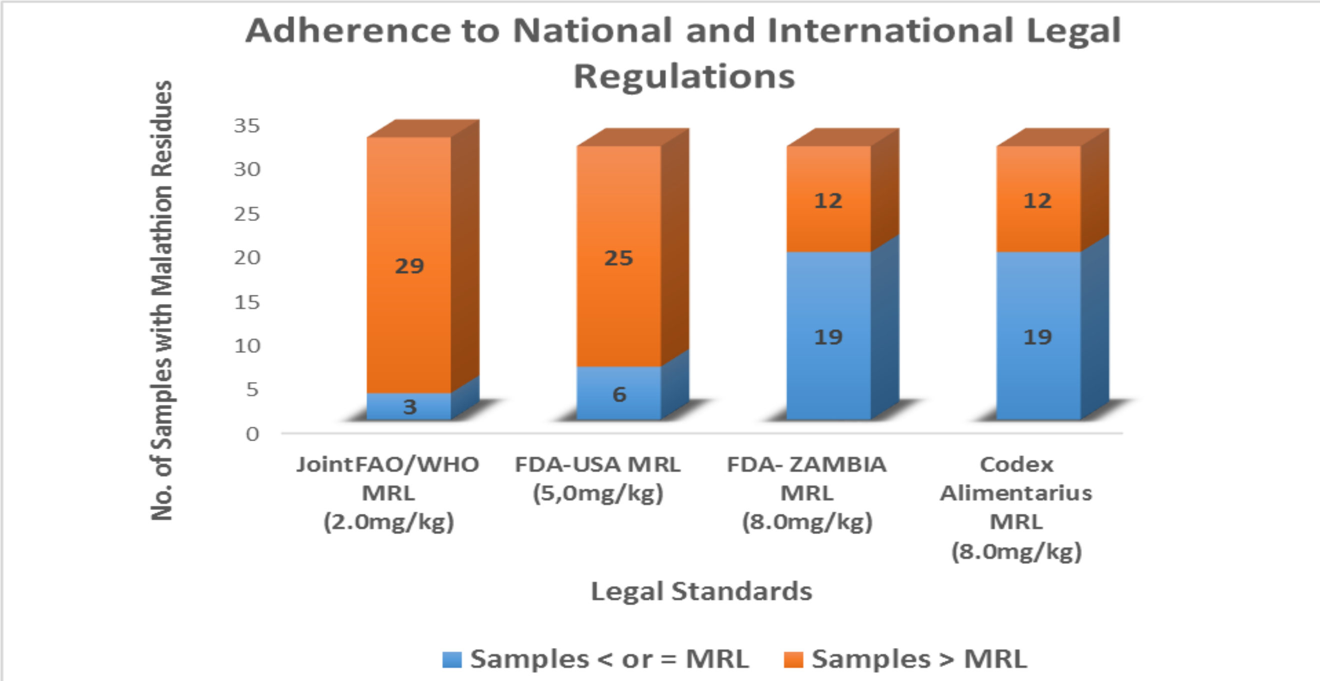

Figure 2. Malathion residue Compliance levels

The figure above shows that even if the Food and drugs regulations of 2001 and codex Alimentarius maximum residue limits are high (8 ppm), not all fresh vegetables were within the allowable maximum residue limits. About 39% of vegetable samples had Malathion concentration above maximum residue limit set by the Food and Drugs Regulation of 2001 of the Laws of Zambia. This was adopted from the Codex Alimentarius commission. Comparing the results with legally acceptable maximum residue limits with other international legal framework such as the joint FAO/WHO, standards only 2 vegetable samples were within the Maximum residue limits. The Food and Drugs Administration standards of the United States of America which has the standard of concentration of 5mg/kg indicated that only 6 out of the 31 samples that had Malathion residues were within the allowable maximum residue limits. Malathion residue quantities in all the thirty one samples ranged between 0.65mg/kg – 19.34 mg/kg. In terms of measure of spread, the data was skewed to the right with the first quartile of 6.49 mg/kg, median being the central portion of the distribution 7.45mg/kg, third quartile of 9.18mg/kg and interquartile range of 2.69mg/kg,

4.3 Social Demographic Profile

The total adult farmer population in the study was forty. Of the forty farmers in the study, 65% were male and 35% were female. The age range was 18 to 65 years with the mean age of 35 ± 5 years old. In the study had either completed primary education (32.5%) or basic education level (35.5%) with only ten (25%) respondents having reached high school level. None of the respondents had acquired any form of tertiary education. The family sizes were fairly big according to rural settings with highest proportion of 42.5% and 35% with average family sizes of five and eight respectively. In terms of vegetable farming experience, only 1 (2.5%) had started farming that season while 39 (97.5%) had been in vegetable farming for more than one year, refer to table 1 below.

Table 2. Profile of Respondents and characterization of presence of Malathion

Characteristic	No. of Respondents (%)	No. of respondents using Malathion (%)	No. of Respondents using malathion > Limits (%)
Age of Respondent in Years			
18 -30	9 (22.5)	6 (19.35)	0 (0)
31 - 40	17 (42.5)	14 (45.16)	5 (41.7)
41 - 50	9 (22.5)	8 (25.81)	5 (41.7)
51 +	5 (12.5)	3 (3.68)	2 (16.7)
Gender of Respondent			
Male	26 (65)	20 (65)	8 (66.7)
Female	14 (35)	11 (35	4 (33.3)
Family Size			
1 - 3	2 (7.50)	2 (6.45)	1 (8.33)
4 - 6	17 (42.50)	13 (41.94)	6 (50.00)
7 - 9	14 (35.00)	10 (32.26)	3 (25.00)
≥ 10	6 (15.00)	6 (19.35)	2 (16.67)
Level of Education			
Never to school	3 (7.50)	2 (6.45)	1 (8.33)

Primary	13 (32.50)	11 (35.48)	3 (25.00)
Basic	14 (35.00)	11 (35.48)	6 (50.00)
High school	10 (25.00)	7 (22.58)	2 (16.67)
Tertiary	0 (0.00)	0 (0.00)	0 (0.00)
Experience in Vegetable farming in Years			
0 ≥ 1	1 (2.50)	1 (3.23)	0 (0.00)
2 ≥ 5	16 (40.00)	13 (41.94)	12 (100)
6 ≥10	13 (32.50)	10 (32.26)	0 (0.00)
> 10	10 (25.00)	7 (22.57)	0 (0.00)

Source: field data 2017

4.4 Sources of Information on Vegetable Production.

Vegetable farmers had no reliable information sources on vegetable production as most of them (32/40 representing 80%) depended on their colleagues for guidance. A total of 36 (90%) farmers got interested in vegetable farming through the inspiration of friends who were able to support their families through vegetable production. It was also observed that only 7 (17%) of farmers had farming information from Agricultural Extension Workers. During the data collection period, the district had no local radio station and only one respondent said at times he gets information from the national radio station channel (Zambia National Broadcasting Corporation). Most farmers demonstrated having low knowledge on the effects of chemical pesticides to animal and environment (water, soil, air) apart from the short term adverse health effects that can be caused if humans are exposed to these pesticides. The most common method of accessing pesticides among farmers were from the local Agro shops (92.5%) while a few (7.5%) were accessing pesticides from their friends. Table 2 below shows the details.

Table 3. Farmer Vegetable Farming & Pesticide Information source: n = 40

Characteristic	No. of Respondents (%)	No. of respondents using Malathion (%)	No. of Respondents using malathion > Limits (%)
Farmer information source			
Friends	32	25 (80.65)	4 (33.33)
Radio	1	1 (3.23)	0 (0.00)
Extension Agriculture staff	7	5 (16.13)	8 (67.67)
Pesticide Knowledge			
Have	40	31 (100.00)	12 (100.00)
Does not have	0	0 (0.00)	0 (0.00)
Harvesting motivation			
Manufacturer instructions	39	30 (96.77)	12 (100.00)
Friends	0	0 (0.00)	0 (0.00)
Market demand	1	1 (3.23)	0 (0.00)
Pesticide source			
Friends	3	3 (9.68)	0 (0.00)
Local shops	37	28 (90.32)	24 (100.00)

Source: field data 2017

4.5 Farm Management

All the farmers were using conventional pesticides in vegetable production. It was found that most (75%) of vegetable farm size was less than a Lima (2500 m^2). Malathion was the most common pesticide (77.5%) used among farmers that were in the study. 96% of respondents adhered to withholding time period with only a few harvesting their crop at not less than seven days after spray. During the study, not all farmers were found with the last pesticides used or any packaging with attached labels on it. Only 27 (67.5%) farmers had the packaging although they still had crops which were being sprayed as shown in table 4.

Table 4. Farmer pesticide and farm Management: n = 40

Characteristic	No. of Respondents	No. of respondents using Malathion (%)
Farm size		
< 1 Lima	30	23 (74.19)
≥ 1 ≤ 2	9	7 (22.58)
> 2 lima	1	1 (3.23)
Farmers using pesticides in Veg production		
Use	40	31 (100.00)
Does not use	0	0 (0.00)
Adherence to Lead time before harvesting		
Adhere (<7 days)	1	1 (3.23)
Does not adhere (≥ 7 days)	39	30 (96.77)
Pesticide Packaging/ label found kept by farmer		
Found	27	22 (70.97)
Not found	13	9 (29.03)

Source: field data 2017

4.6 Analysis of Data Results

After data was collected from the small scale farmers that were included in the sample, it was analysed using the Stata software in determining the effects of the above variables / predictors with levels of Malathion pesticide residues as a dependent variable. Data was first analysed as unadjusted (simple logistic regression model) and later as Adjusted (multiple logistic regression). Below are the results obtained after computation of data in statistical Stata software package

Table 5: Bivariate and Multivariate analysis of factors associated with Malathion residues in fresh vegetables produced by small scale farmers of Chinsali district

Values		Bivariate (Unadjusted) Values			Multivariate (Adjusted)		
CHARACTERISTICS	**No. of participants (%)**	**P- Value**	**Unadjusted Odds Ratio**	**confidence Interval (CI)**	**P- Value**	**Adjusted Odds Ratio**	**CI**
Gender							
Male	26 (65.0)	**ref**					
Female	14 (35.0)	0.849	0.036	-0.350, 0.422			
Age of Farmer in Years							
18. - 30	9 (22,5)	**ref**					
31 - 40	17 (42.5)	0.0001*	2.35	1.67, 3.32			
41 - 50	9 (22.5)	0.0001*	2.35	1.67, 3.32	*0.0001**	**1.5**	-1.27, -0.52
51 +	5 (12.5)	0.0001*	5.8	1.08, 3.22	0.001*	**0.4**	-1.37, -0.43
Level of Education							
None	3 (7.5)	**ref**					
Primary	13 (32.5)	0.532	2.67	0.123, 57.620			
Basic	14 (35.0)	0.906	0.83	0.040, 16.994			
High school	10 (25.0)	0.577	2.5	0.099, 62.604			
Agriculture Camp							
Chinsali Central	18 (45.00)	**ref**					
FTC	17 (42.50)	0.067	0.21	0.0388, 1.114			
Chibesa	5 (12.50)	0.766	1.45	0.1228, 17.233			
Farm size							
Less than 1 Lima	2 (7.5)	**ref**					

At least 1 Lima not greater than 2 Lima	31 (77.5)	0.86	0.85	0.154, 4.764			
Greater than 2 lima	6 (15.0)		-				
Source of Pesticide							
Friends	3 (92.5)	**ref**					
Local Shops	37 (7.5)	0.063	12	0.87, 165.4			
Farmer main source of information							
Friends	32 (80.0)	**ref**					
Agriculture Ext staff	7 (17.5)	0.410	2.67	0.259, 27.485			
Radio	1 (2.5)						
Pesticide Information source							
Friends	33 (82.5)	**ref**					
Agriculture Ext staff	7 (17.5)	0.186	0.36	0.081, 1.640			
Vegetable Type							
Tomato	21 (52.5)	**ref**					
Rape	19 (47.5)	0.226	0.22	-0.146, 0.594			
Pesticide Package/container found							
Package/ container found	27 (67.5)	**ref**					
Package/container not found	13 (32.5)	**0.042***	0.67	-0.773, -0.015	0.848	1.03	-0.29, 0.36
Knowledge on Environmental Effect							
Have knowledge	33 (82.5)	**ref**					
Have no knowledge	7 (17.5)	**0.030***	1.6	0.049, 0.911	0.009*	**0.612**	-0.85, -0.13
Read label Instructions							
Able to read	36 (90.0)	**ref**					
Not able to read	4 (10.0)	0.260	1.5	-0.322, 1.1502			

Source: field data- 2017 ****p<0.05*** ***CI (95%)***

From the above table, when variables were put in the simple logistic regression model (Unadjusted) as single variables, age, Pesticide Package/container found, and Farmer having knowledge on effects of pesticides to the environment were significant. There was no association between the dependent and every single independent variable. This may be as a result of confounders that were not taken care of. Hence we tried to look at all those variables with p-Value < 0.05 to be used in the multiple regression model. From the above univariate logistic regression model the following characteristics with P- value < 0.05 were fitted at once in the multiple (adjusted) logistic model to control for confounders. Results to the right columns of table five were obtained

4.7 Description of multiple (Adjusted) Logistic Regression results of table 5

The variables were all fitted in the multiple logistic regression model at once and the output obtained were adjusted for all the characteristics that were statistically significant in bivariate logistic regression. In the multivariate logistic regression model, it was noted that Pesticide packaging / label of applied pesticide to the vegetable sampled was not statistically significant. (P = 0.848, CI: -0.29, 0.36). The other two variables that included age of a farmer and Farmers knowledge on effects of pesticides to the environment were statistically significant as highlighted in bold in table above. This implies that there was an association between the above three variables and high concentration of pesticide residues (> 8mg/kg) in fresh vegetables produced by small scale farmers of Chinsali district. It was realized that, at 95% confidence interval, farmers in age category 41 to 50 years were 50% times more likely to produce vegetables with malathion residues greater than the maximum residue limit, conversely farmers in age category 51 years and above were 40% less likely to produce vegetables of high concentration of malathion residues in fresh vegetables as compared to those in age category 18 to 30 years old. In this study, it was also established that the odds of producing fresh vegetables with malathion residues above MRL was 60% less likely to among farmers with less knowledge on pesticide effects to the environment as compared to those farmers with some knowledge on effects of pesticides to the environment (P-value 0.009, 95% CI: -0.85, -0.13).

CHAPTER FIVE

DISCUSSION

Fresh vegetable production is done by small scale farmers in Chinsali who either are doing it as backyard gardening for home consumption or as their main source of income apart from grain growing. This type of vegetable production is not only peculiar to Chinsali but also in most parts of Zambia and developing countries where most vegetables are produced by small scale or peasant farmers (mayank and Ajay, 2007).

5.1 Malathion Residue levels and legal compliance

All small scale farmers of Chinsali that were recruited in the study were using synthetic pesticides in vegetable production. Although they were aware of the lead time expected to be observed before harvesting, they were not very keen to understand the levels of pesticide residues that were left on fresh

5.2 Factors Associated with Malathion Residues in Fresh vegetables

5.2.1 Age of a farmer

With reference to the age category of 18 to 30 years, farmers tend to produce high pesticide residue concentration in fresh vegetables as they are at ages between 41 to 50 years. During cross tabulation between age and level of education, results revealed that no farmer in age category 41-50 years old had reached grade twelve. Most of them ended in primary education. Conversely, farmers with age category 50 and above were producing vegetables with low residue concentration because the highest percentage among them had reached grade twelve as compared to those in age category 18 to 30 years old. There was a direct relationship between levels of education and Malathion residue concentration I fresh vegetables. The study revealed that farmers with low education were directly related to production of vegetables that have high concentration of pesticide residues. The same was discovered by Donkor et al, 2016 in Ghana where they attributed those misuse pesticides to be more among less educated farmers. These type of farmers were supposed to be supported through adequate extension services but it was found that agriculture extension officers were not visiting the vegetable farmers most often.

5.2.2 Knowledge on Environmental Effects of Pesticides

Inadequate knowledge on effects of pesticides on water, soil, air and other vegetative growth showed no effect no pesticide residue concentration in vegetables. The association was centrally to the expected result. In the normal sense those with knowledge would have been producing vegetables with low pesticide residues and yet not. The farmers' interest was producing plesant appearance vegetables without considering the pesticide residue quantity deposited on vegetables. They are very much interested in market value of their produce other than any negative health and environmental impact theses vegetables may cause due to high concentration of pesticide pesticides. The study by Elodie et al, 2010 revealed that even commercial farmers with adequate knowledge and appropriate equipment were producing vegetables with high pesticide residue concentration (Elodie, et al, 2010), their much concern was producing vegetable that is appealing in the eyes of the consumer. Another study by Padmajani et al, 2014 found similar results that a farmer can also use any pesticide with any quantity to protect the produce regardless having prior knowledge on pesticide effects to the environment.

5.3 Study Limitations

The measure of pesticide residues was limited to unprocessed rape and tomato samples collected. The study would have been able to look at most pesticides that are being used by the small scale farmers to determine their residue concentrations after harvesting however, high operational costs on data collection, transportation and laboratory analysis limited the study to analyze only one among the most common Chemical pesticides from the samples. The control of confounders was limited to the above stated ones, otherwise the results might have been influenced by other confounders which were not considered in the study. The sizeable number of vegetable samples were collected equivalent to the number of small scale farmers that were able to fit within the available resources and able to give optimal reliability of the results. The study was designed not to go beyond the determination of maximum residue concentration due to limited time frame but further studies can be done to estimate the average daily intake of the vegetables in order to determine the health effects of the pesticide residues in Fresh vegetables.

5.4 Conclusion

The study revealed that Malathion is a commonly used pesticide in vegetable farming in Chinsali district. About forty percent of vegetables produced have malathion residue limit levels higher than the maximum residue limits stipulated in the Food and drugs regulations of 2001 of the Laws of Zambia. The deviation above the authorized Maximum Residue Limit of 8.0 mg/kg is higher in tomato than rape (brassica napus). The main factors that were found to be associated with high concentration of Malathion residues in Fresh vegetables age and low knowledge levels among farmers on the effects of pesticides to the Environment. The two factors can be directly linked to low levels of education and lack of training before and during vegetable production.

5.5 Recommendations

In order to improve quality of vegetables that is free from excess of Malathion and any other pesticide residue concentrations in Chinsali district and any other places in Zambia with similar challenges,

5.5.1 Department of Agriculture

More vigorous programmes should be introduced by the department of Agriculture in partnership with stakeholders in vegetable farmer Education. This can be done by engaging the community radio stations such as Muchinga radio station as the case for Chinsali to help air programmes on vegetable production and pesticide management.

Increased farmer contact by the Agriculture extension staff cannot be over emphasized knowing the low education levels among vegetable farmers that cannot mostly depend on print information.

5.5.2 Ministry of Health

Food quality monitoring is a mandate of the Ministry of Health in Zambia. Strengthening food quality monitoring systems throughout the food chain system coupled with research can help in awareness creation among the population and inform policy makers.

5.5.3 Environmental Management agency

The Environmental management agency should show presence in all parts of the country so that area specific programmes can be formulated to help mitigate problems arising from pesticide use. ZEMA with the department of agriculture should institute monitoring the sale of pesticides among agro shop owners so that competent personnel are manning shops that can be able to guide farmers on the correct use and choice on pesticides. Farmers should also be adequately monitored so that pesticides are used in accordance with the stipulated guidelines and legal framework.

5.5.4 Community

Fresh vegetables for home consumption bought or produced from unknown sources must be adequately processed before consumption. This include thorough washing of vegetables with adequate clean water and passing the washed vegetables in boiled water (Satpathy et al, 2012). Studies show that washing and peeling removes 99% of carbonyl and Malathion residues from tomatoes (Elkins, 1989). Fresh vegetables should be adequately cooked. Preparation of vegetable salads should not be encouraged from vegetables of unknown and unreliable sources. Among all the methods utilized direct cooking and washing with 2% salt solution were most effective (Rao *et al*, (2014).

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APPENDICES

Appendix A Participant Information Sheet

Reading level 8.0

University of Zambia, School of Medicine, Department of Public Health

Study Title: Pesticide residues on selected fresh vegetables sold in markets of Chinsali District

Principal Investigator: Bernard Mwansa

ERES Converge NO:

Purpose of research project

This study is part of my practicum for my training in Public Health, which I am doing with the University of Zambia. The purpose of the study is to fulfill my study in masters of Public Health at the University of Zambia, School of Medicine. To do so, I first want to buy a heap of fresh rape or Tomato from you that you have come to sale at this market. The rape or tomato I will buy from you will be taken to the laboratory to check if there are pesticides. I also intend to visit you at your home to find out how you grow these vegetables.

Why you are being asked to participate?

Potential participants for the study are small scale vegetable farmers of Chinsali Central and FTC farming camps. If you accept to participate and sign the consent form, you will be part of the study because you are among suppliers of fresh vegetables sold at Chinsali main market and Location market. You have been asked to participate because you fit these descriptions. Overall, I expect about 40 vegetable farmers to participate in this study.

Procedures

If you agree to participate in the study

- I will request you to sale me some vegetables. I will ask you to take part in interview at the day convenient to you at your home. This interview will take about 30 minutes. It will be done in a private place. If you permit me, during that interview, I will come with some questions on the papers. Your answers will be recorded in this same question paper. I will ask you if it will be ok for me to write notes. The information from tape or notes will be typed in full, to help me to fully understand what you will say. Your name will not be included on this question paper.

If you are participating in the study, I will be asking you questions from this question paper

- In this questionnaire, I will ask you what type of vegetables you grow. How you grow them. Types of insects that eat your vegetables when they are growing. Types of medicine you use to control these insects.
- I will also ask you how you know the types of medicines to use for different insects and diseases. When vegetables are sprayed with this medicine, what time do you allow for medicine to Work before applying another? I will also ask on the time you allow for medicines to work before taking vegetables to the markets.

Risks/discomforts

There are no physical risks to participating in this study. However, I feel some information you may tell me may be personal or may affect your thinking. But, I would like to assure you the information that we get from you will not be shared with anyone outside the research study. You are free to decline answering any questions that you may not be comfortable with or otherwise

Benefits

If you are participating in the research study, you will gain some knowledge on medicine to use when insects attack your vegetables. The study will also help to inform the Agriculture staff on your needs. This will help you to improve knowledge in vegetable growing. These benefits may directly help you and other vegetable farmers.

Payment

There is no payment for participating in the study.

Protecting data confidentiality

I have put up steps to protect the information I will get from you. First, only my research assistants and I will have access to the information. The collected data will be locked in a secured place. I will destroy all data within one year after typing the information. Vegetables bought from you shall be thrown by the laboratory staff after analysis as per national guidelines.

What happens if you do not want to participate in either the study or don't sale me the vegetables?

You are free to decide whether you want to sale me the vegetables or to take part in the answering of the questionnaire. This will not bring any problem to you.

Who do I call if I have questions or problems?

- Call me, <<Mr. Bernard Mwansa>>, at <<+260-967210673 or 0977210673>> if you have questions and complaints about the study.
  Postal Address: Muchinga Provincial Medical Office
  P.O. Box 480021
  Chinsali

- Call or contact the ERES Converge IRB Office for any ethical queries. The Ethics Committee contact information is:

Physical Address: The Chairperson

ERES Converge IRB

33 Joseph Mwilwa Road

Rhodes Park,

Lusaka

Zambia

Telephone: +260 955 155633 or +260 955 155 634

E-mail: eresconverge@yahoo.co.uk

What does your signature (or thumbprint/mark) on this consent form mean?

Your signature (or thumbprint/mark) on this form means:

- You have been informed about the program's purpose, procedures, possible benefits and risks.
- You have been given the chance to ask questions before you sign.
- You have voluntarily agreed to be in this program

_________________________ _____________________________ __________

Print name of Adult Participant Signature of Adult Participant Date

_________________________ _____________________________ __________

Print name of Person Obtaining Consent Signature of Person Obtaining Consent Date

Ask the participant to mark a "left thumb impression" in this box if the participant (or participant's parent) is unable to provide a signature above

Appendix B. Participant consent form

CONSENT FORM FOR PARTICIPATION IN RESEARCH

(By interview,)

Study on pesticide residues on selected fresh vegetables and associated factors in Chinsali District

I

…..

being over the age of 18 years hereby consent to participate as requested in the research project on Pesticide residues in Fresh vegetables produced by small scale farmers in Chinsali district and associated factors

1. I have read the information provided.
2. The details of procedures and any risks have been explained to my satisfaction.
3. I agree to answer questions for the questionnaire during my participation
4. I am aware that I should retain a copy of the Information Sheet and Consent Form for future reference.
5. I understand that:
   - I may not directly benefit from taking part in this research.
   - I am free to withdraw from the study at any time and I am free to decline to answer particular questions.
   - While the information gained in this study will be published as explained, I will not be identified, and individual information will remain confidential.
   - Whether I participate or not, or withdraw after participating, It will have no effect on any treatment or service that is being provided to me.
   - Whether I participate or not, or withdraw after participating, It will have no effect on my livelihood as pertains to vegetable growing and selling.

- I may ask that the observation to be stopped at any time, and that I may withdraw at any time from the session or the research without disadvantage.

6. I agree/do not agree that the information recorded on the questionnaire being made available to other researchers who are not members of this research team, but who are judged by the research team to be doing related research, on condition that my identity is not revealed.

7. I have had the opportunity to discuss taking part in this research with a family member or friend.

Participant's signature……………………………………………… Date……..……………...

I certify that I have explained the study to the volunteer and consider that she/he understands what is involved and freely consents to participation.

Researcher's name ....

Researcher's signature…………………………….…….. Date…………………….…….

NB: Two signed copies should be obtained. The copy retained by the researcher may then be used for authorisation of Items 8 and 9, as appropriate.

4. I the participant whose signature appears below, have read a transcript of my participation and agree to its use by the researcher as explained.

Participant's signature…………………………… Date…………………...............................

9. I, the participant whose signature appears below, have read the researcher's report and agree to the publication of my information as reported.

Participant's signature………………………… Date…………………...................................

Thumb Print

Appendix C. Research Questionnaire

UNIVERSITY OF ZAMBIA

SCHOOL OF MEDICINE

Department of Public Health

QUESTIONNAIRE

Study on Pesticide residues in fresh vegetables sold in Markets of Chinsali District

Bernard Mwansa
Student No. 514700513

MPH (Environmental Health)

Supervisors: **Dr. Halwiindi H**
Ms. Patricia Mubita
Mr. Yoram Siulapwa

Structured questionnaire for data collection on Pesticide residues in fresh vegetables sold in Markets of Chinsali District

Small scale Vegetable Farmers

Instructions

I. Greet respondents
II. Introduce yourself
III. Explain purpose of the study
IV. Do not write respondents name to ensure anonymity
V. Explain that the information given is confidential
VI. Kindly put answer in provided spaces as per instruction
VII. Thank the respondent after interview

RESPONDENTS QUESTIONNAIRE **CODE #** [ ]

A. PRELIMINARIES

Name of District.. Date of Interview..

Name of Village/Farming area..................................Name of Interviewer.....................................

Name of Agriculture camp..Name of Chiefdom…………………………

B. PERSONAL SOCIAL DETAILS

1. How old are you? Mark [X] where appropriate
   1. [<25yrs =1] [1]
   2. [25yrs-35yrs =2] [2]
   3. [>35yrs =3] [3]

2. Indicate sex /Gender of respondent: Male (1) [ ] Female (2) [ ]

3. How many persons live with you at this home [1-3 = 1], [4-6 =2], [7-9 = 3], [10 and above, 4] Mark [X] in appropriate box [1] [2] [3] [4]

4. What is the size of your vegetable farm? Mark [X] in appropriate box
   1. [<1 lima =1], [1]
   2. [1-2 lima= 2], [2]
   3. [>1lima =2] [3]

5. Do you belong to any club or association that supports you in vegetable farming (**If no, go to question No. 8)** If yes write 1, if no,2 in the box provided

1. Yes ☐ 2. No ☐

6. If yes, what type of support / assistance do you receive from or through this association/ club?

   1. Monetary Support ☐
   2. Knowledge/ Training ☐
   3. Monetary and training/ knowledge ☐
   4. Other form of support (seed, agric chemicals, market, Equipment etc) ☐
   5. No any form of support received ☐

C. VEGETABLE FARMING EXPERIENCE

7. For how long have you been in vegetable (rape, cabbage, tomato, Chinese cabbage) growing for sale? 0-1yr = 1, 2-5yrs=2, 6-10yrs = 3, >10yrs =4 (indicate number in the box provided below) ☐

8. What made you to engage in Vegetable farming? (Fill appropriate number in the adjacent box to each possible answer)

   1. Visit and support from Agricultural Extension workers ☐
   2. Friends engaged in vegetable growing ☐
   3. Information from media (print, radio/Television, ☐

D. KNOWLEDGE ON VEGETABLE PESTICIDE USE

9. What is your major information source in vegetable farming?
   1. Friends ☐
   2. Radio ☐
   3. News paper/fliers ☐

4. Agriculture Extension staff ☐

10. Do you use any pesticides in the production of vegetables? Yes= 1, No = 2 ☐

11. Do you know the types of pesticides that you apply during vegetable (rape/ Tomato) production?

1. Yes ☐
2. No ☐

12. Where do you get the information on the use of pesticide?

1. Friends ☐
2. Radio ☐
3. Newspaper/fliers ☐
4. Extension Agric staff ☐

13. What last pesticide did you use before the harvest of the Rape/ tomato I bought from you?

1. Malathion ☐
2. Other (Specify name with active ingredient) ………………………….. ☐

14. When did you apply the pesticide on the crop (rape/tomato)

1. Less than 2 days ago ☐
2. 2-4 days ago ☐

3. 5 -6 days ago
4. 7 days and more days ago

15. How long did it take from the time of pesticide application to the time you started harvesting the vegetables?
    1. Less than 2 days before harvest
    2. 2-4 days before harvest
    3. 5-6 days and above before harvest
    4. 7 days and above before harvest

16. What made you to start harvesting vegetables at that time? (Indicate appropriate number in the box)
    1. Followed instructions from the pesticide label
    2. Informed by friends that the vegetable was ready to harvest
    3. Demand for the vegetables at the market

17. Do you have the remains or packaging of the pesticide you last applied on your Vegetables?

18. Where did you got the pesticides?
    1. Friends
    2. Local shops (within the district of Chinsali)
    3. Outside Chinsali but within Zambia
    4. From neighbouring country (Tanzania, Malawi)

19. Do you know the names of pesticides? Yes = 1, No = 2

20. Do you think that pesticides affect human health? [Yes = 1, No = 2]

21. Do you think that pesticides affect livestock? [Yes = 1, No = 2]

22. Do you think that pesticides affect environment (water bodies)? [Yes = 1, No = 2]

23. Do you ever read pesticides labels? [Yes = 1, No = 2]

24. What methods and tools do you use for measuring of pesticides before dilution [insert appropriate answer in the box]
    1. Calibrated measuring cylinder/ measuring scale
    2. Other equipment such as non-calibrated lid, cup, spoon or other vessel

25. What methods and tools do you use in application of the pesticides to the vegetables
    1. Sprayer pump /other recommended pesticide application Equipment
    2. Other chemical application equipment/ tool (not recommended by Manufacturer / Agriculture Authorities)

END OF INTERVIEW

Thank you for your time and contribution

Appendix D. List of Areas of study

FTC Agricultural Camp		**Chinsali Central Agriculture Camp**		**Chibesa Camp**
No.	**Village**	**No.**	**Village**	**Village**
1	Chinunda	1	Kapululu	Lubwa
2	Mutale	2	Shambalakale	
3	Mulomfi	3	Mafupa	
4	Muinga	4	Lameck	
5	Luko	5	Mwalala	

SOURCE: Chinsali District Agricultural Coordinator's Office

Appendix E Coding of Samples

NAME OF VEGETABLE	NUMBER	ABREVIATION	MAIN MARKET	LOCATION MARKET	DATE MONTH.	SAMPLE NUMBER(Example)
Rape	03	RP	MM	LM	08.22	RP/03/LM/08.22
Tomato	04	TM	MM	LM	08.22	TM/04/LM/08.22

Appendix F List of Independent Variables (Socio- Demographic characteristics)

VARIABLE NAME	VARIABLE SIGN	MEASUREMENT	CODING
Age of respondents	*AGERESPN*	Years	<25yrs =1, 25yrs-35yrs =2, >35yrs =3
Sex of Respondent			
Number of	*SEXRESPN*	Male/Female	Male=1, Female=2
extension contact	*EXTENVST*	Quarterly	0 visit in Qtr = 0, 1-2Qtr =1, >2 Qtr =3
Farm Location			
	FARMLOC	Agric Camp	CC, FTC, CHIB
Vegetable farming			
experience	*FARMEXP*	Years	0-1yr = 1, 2-5yrs=2, 6-10yrs = 3, >10yrs =4
Farm size	*FARMSIZE*	Lima	<1 lima =1, >1lima =2
Household size	*HHLDSIZE*	(0.25hectare)	1-4= 1, above 5=2
Level of education	*LEVEDUCA*	Prim, Second,	Primary=1, Secondary=2, Tertiary=3
		Tertiary	
Membership of association			
	MEMBASSO	Yes/ no	Yes = 1, No = 0
Support from association			
	SUPP ASSO	Monetary/	Monetary =1, Knowledge = 2, Both =3
Credit access			
		Knowledge	
Major information			
source	*CREDTACC*	Yes/No	Yes=1, No= 0
Friends	*INFOSOUR*	XXXXX	XXXXXXXXXXXXXXXXXXXXXXX

Radio	FREND	Yes/No	Yes=1, No = 0
Newspaper/fliers	RADIO	Yes/ No	Yes=1, No = 0
Extension Agric staff	PRINT	Yes/No	Yes=1, No = 0
	EXTAGRIC	Yes/No	Yes=1, No = 0

Appendix G Management and Operation Independent Variables

Name of Variable	Variable Sign	Measurement	Coding
IMPORTANT LABEL INSTRUCTIONS	Xxxxxx	Xxxxx	XXXX
Label found on pesticide package	LABFOUN	Yes/No	Yes= 1. No= 0
Label have English language	LABENG	Yes/No	Yes= 1. No= 0
Farmer able to identify pesticide use	FARMIDE	Yes/No	Yes= 1. No= 0
Farmer able to read label instruction	FARMREAD	Yes/No	Yes= 1. No= 0
IMPORTANT LABEL INFORMATION	XXXXXX	XXXXXX	XXXXXXXXXX
Active ingredient	ACTINGRE	Yes/No	Yes= 1. No= 0
Recommended use	RECOUSE	Yes/No	Yes= 1. No= 0
Formulation	FORM	Yes/No	Yes= 1. No= 0
Dilution Instructions available	DILINST	Yes/No	Yes= 1. No= 0
Waiting Time Information Available	WAITIME	Yes/No	Yes= 1. No= 0
AVAILABILITY OF PEST APPLICATION TOOLS	XXXXX	XXXXX	XXXXXXXXXX
Measuring cylinder/Measuring scale	MEASTOOL	Yes/No	Yes= 1. No= 0
Sprayer pump (other Recommended Equipment)	SPRPMP	Yes/No	Yes= 1. No= 0

Appendix H. Food sampling form

REPUBLIC OF ZAMBIA
MINISTRY OF HEALTH
SAMPLING FORM

FOOD AND DRUGS ACT CAP 303 OF THE LAWS OF ZAMBIA

<table>
<tr><td colspan="4">1. Sample No.</td><td colspan="3">2. Date collected</td></tr>
<tr><td colspan="7">3. (a) Product name and description: ……………………………………………………………
…………………………………………………………………………………………………...
(b) Method of collections: ……………………………………………………………………….
(c) Collector’s identity on package and seal: ……………………………………………………….</td></tr>
<tr><td colspan="7">4. Reason for collection:</td></tr>
<tr><td colspan="4">5. Manufacturer:</td><td colspan="3">6. Dealer:</td></tr>
<tr><td colspan="4">7. Size of lot sampled:</td><td colspan="3">8. Date dispatched:</td></tr>
<tr><td colspan="2">9. Delivered to:</td><td colspan="2">10. Date:</td><td colspan="3">11. Laboratory:</td></tr>
<tr><td rowspan="2">12. Records obtained</td><td colspan="4">(a) Invoice No. and date</td><td colspan="2"></td></tr>
<tr><td colspan="6">(b) Other documents:</td></tr>
<tr><td colspan="3">13. Sample cost:</td><td colspan="4">14. Collectors (Print Name & Signature)</td></tr>
</table>

Source: *Food and Drugs Act CAP 303 of the Laws of Zambia.*