DETERMINATION OF PESTICIDE RESIDUES ON SOME COMMODITIES IN THE UNITED ARAB EMIRATES

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DECLARATION OF ORIGINALITY

This thesis reports the original work of the author, except as otherwise stated. It has not been submitted previously for a degree at any university.

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ABSTRACT

Pesticide residues in foodstuffs are considered a world wide problem because of their impact on human health; therefore, different studies have been conducted in this field. The results of these studies often do not confirm that harmful effects on human health do occur.

In the UAE there is little information about this vital problem, as a result, this study was designed to add some data to enable more detailed and wide ranging, monitoring and continuous studies.

The survey on pesticide residues, in this study, was concerned only with two vegetables (tomato & cucumber) and five pesticides, which are commonly used in plant protection programs (Dimethoate, Chlorpyrifos, Metalaxyl, Diazinon and Chlorothalonil). This study found that there were only rare instances of pesticide residues detected which were above the acceptable safety limits. This may be due to good agricultural practice and assisted by the high environmental temperatures, which assist with the natural decomposition of pesticides in the field.

On the other hand, collection of information on the level of public concern about this issue, indicated that, there is, to some extent, concern in the community about these issues.

This level of concern seemed to differ between male and female respondents and also between national and non-nationals in the UAE.

Therefore, this study considered the first thesis, which has been conducted to evaluate the presence of pesticide residues and their related public issues in the UAE.

As a result of these studies, the following recommendations are made.

In order to raise the public interest, condensed and simple scientifically based print, TV or radio programs should be produced to illustrate the benefits and hazards of using pesticides in plant protection programs, and how the user of pesticides may take care to prevent environmental pollution and to promote the safe use of pesticides.

A cooperative advertising program should be organized by the Ministry of Agriculture and Fisheries and different agricultural departments within the United Arab Emirates, to promote a balanced view on the uses and benefits of pesticides to the community.

The results of these studies indicated that, no serious cases of pesticide contamination were detected in the foodstuffs under investigation. However, as there is no scientific research center for follow up programs for monitoring pesticide residues in the UAE, a recommendation can be made to establish a center of this type, to provide routine monitoring of the produce available to the public in this nation.

As it will take some time to establish such a center, in the meantime, short cooperative studies designed to regularly monitor pesticide residue levels in foodstuffs should be conducted. These studies should be expanded to include a wider range of fruit and vegetables and also to include a wider range of pesticides. Such work can be done with the cooperation of:

- The Ministry of Agriculture and Fisheries.
- Food Quality Labs in each emirate.
- The Environment Research and Wildlife Development Agency (ERWDA).
  The Federal Environmental Agency (FEA).

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GLOSSARY

Multi-residue Methods (MRMs)

Methods that can analyze food for many pesticides in a single analysis. Therefore, they are highly desirable, and consequently provide the basis for meeting monitoring needs of all agencies. They may be used by food processors, retailers, and consumer advocate groups, as well as by federal and state regulatory agencies. MRMs are designed to handle a large sample volume with relatively quick turn-around times.

Acceptable daily intake (ADI)

The acceptable daily intake (ADI) for humans is an estimate of the amount of a chemical that can be ingested daily over an entire lifetime without an appreciable risk to health. It is calculated by applying a safe factor to the overall, no-observable-effect level determined in toxicity studies.

No-Observable Effect Level (NOEL)

The highest daily dose of a pesticide that does not cause harm in experimental animals.

Maximum Permitted Concentration (MPC)

MPC is similar to the maximum residue limit, but applies to naturally occurring elements such as heavy metals.

Provisional Tolerable Weekly Intake (PTWI)

PTWI of a contaminant is relevant to chronic intakes, not acute toxicity. They are set for substances such as heavy metals that are unintentional contaminants of the environment and are known to accumulate in the biosphere.

LD_{50}

The dose of a chemical that kills 50 percent of the test animals to which it is administered under experimental conditions. It is expressed as mg/kg of body weight. However, this value is used to express mammalian toxicity, and is measured in terms of oral (fed to, or placed directly in the stomach of rats), dermal (applied to the skin of rats and rabbits), and inhalation (Ware, 1991). The size of the dose is the most important single item in determining the safety of a given chemical. According to Gerozisis and Hadlington (1995), the toxicity data available as LD_{50} are not an absolute measure of toxicity to humans (mammalians). They stated that, broadly, LD_{50} measures are used only as an approximate guide to the relative toxicity.

1.0 INTRODUCTION & AIM OF THE WORK

1.1 INTRODUCTION

Our increasingly stressful life style combined with the fact that we live in a chemically complex world, with chemical additives in the food we eat, residues of chemicals on agricultural commodities, chemicals present in every day cleaning compounds, chemicals in the air we breath as a result of spraying pesticides to control pests in our homes and gardens, from cosmetics and deodorants, make it virtually impossible to determine to what extent the precise effect of a particular chemical may have on a particular individual.

The environmental concern over such issues, worldwide, has increased in the last ten years with special attention to the impact of agrochemicals as a health threat to humans and their environment. Also, the effects of pesticides on non-target organisms and the environment has received much attention for more than a decade. This has been the basis of most legislation intended to control or prohibit the use of specific pesticides (Ware, 1983). It is well known that the use of agrochemicals is an indispensable tool, which supports the complex array of market, and economic regulations that affect the price, quality and availability of food.

It was estimated that insects, weeds, plant diseases and nematodes account for losses exceeding 30 billion US dollar annually in the U.S. alone (Ware, 1991). Where as the use of pesticides in agriculture make it possible to save approximately one-third of our crops. The picture is clearer in the field of public health where some fatal diseases such as malaria and yellow fever, which are transmitted by insects, are controlled well by using pesticides. The use of pesticides has greatly reduced the mortality rate among the people resident in such epidemic areas.

The role of pesticides in crop protection is well known as they are used as curative and protective tools. These will directly protect the crops and consequently increase their production. The ever-growing population worldwide needs food, shelter and fibre and this is dependent upon successful use of crop protection programs.

Pesticides if properly used will produce a satisfactory result, but at the same time their misuse will result in drastic effects both to the environment and human health. Careless use of pesticides has lead to accidents and environmental pollution. However the use of these chemicals both in the field of agriculture and public health is correlated with cultural, economic and to some extent social factors prevailing in society.

Under the U.A.E conditions of vegetable production, tomato and cucumber have priority due to their high market price. On the other hand, the policy followed for their marketing encourages high production which may to some extent lead to relatively high useage of pesticides, this can be attributed to the fact that most farm managers have a poor understanding about the safe and correct use of pesticides. This will reflect on the choice of chemicals and when and how they are used.

The public in the U.A.E have been affected to some extent by this concept and actively seek pesticide free commodities. Despite the efforts by the agricultural departments to ensure the correct use of pesticides, this concept still persists among members of the public.

From this issue the question, is raised "to what extent are locally produced commodities safe and edible" Scattered limited studies have been done to answer this question but unfortunately they are not documented. The present study is the first one in an M.Sc. or Ph.D. program in U.A.E to adress this problem.

Another consideration is the relative toxicity (at time of application) and the persistence (relative rate of decay) of pesticides. These two factors greatly influence the safety of chemicals either at the application or at the point of consumption. Consideration of these two factors can greatly influence the selection of pesticides with respect to human health issues.

1.2 THE AIM OF THE PRESENT STUDY

This study has two main aims:

1 To evaluate the identity and range of residues of commonly used pesticides on and in locally produced and imported tomato and cucumber through extensive survey of the market by random sampling. The survey will cover the major Agricultural areas in the U.A.E, and different production areas in Queensland, (Australia).

2 To design and conduct a consumer and retailer survey to develop an understanding of the level of public awareness and concern about issues of pesticide residues in the market place.

2.0 LITERATURE REVIEW

2.1 DEFINITIONS

2.1.1 PESTICIDE

The most appropriate definition of pesticide is that applied by the most state and federal laws in U.S.A: A Pesticide is an "economic poison" defined as any substances used for controlling, preventing, destroying, repelling or mitigating any pest. This includes fungicides, herbicides, insecticides, nematicides, rodenticides, desiccants, defoliants and plant growth regulators. Another definition is "any substance or mixture of substances used to prevent, destroy, repel or reduce the harmful effects of any insects, rodents, nematodes, fungi, bacteria or weeds".

The word "pesticide" means "pest killing" where is a suffix '-cide' comes from Latin meaning to kill. Table (1), illustrates the different classes of pesticides and their uses.

According to Van Emden and Peakall (1996) chemicals can be classified either by their chemical composition or by the uses to which they are put. Included as pesticides are groups of chemicals that do not actually kills pests. However, because of their uses they fit rather practically and legally into this group. Among these are the growth regulators, which stimulate or retard growth of the plants and sometimes crop defoliants which remove leaves or speed drying of plants; desiccants, which are used for mechanizing work in harvesting cotton, soybeans, potatoes and other crops (Table 2).

The term pesticide also applies to compound used as repellants, attractants and insect sterilants. However, this last group does not precisely fit the original definition but rather the legal definition of the term pesticide (Ware, 1991).

2.1.2 PESTICIDE RESIDUES

These are pesticide deposits, which persist after application, or are pesticide metabolites (break down products) produced from the original pesticide by biological, chemical or physical degradation. They may be located in plant, or animal tissues, in soil, water, or air. For some compounds, according to Food and Agricultural Organization (FAO, 1997), it may be necessary to establish separate residue definitions for enforcement and for dietary intake purposes. The residue definition for dietary intake purposes should include metabolites and degradation products of toxicological concern irrespective of their source, where as, the residue definition for compliance with the Maximum Residue Limit (MRL) needs to be a simple residue definition suitable for practical routine monitoring and enforcement of the MRL at a reasonable cost.

Although metabolites, degradation products and impurities are included in the definition of pesticide residues, this does not necessarily mean that metabolites or degradation products should always be included in the residue definition for enforcement purposes or for estimation of dietary intake. Inclusion of metabolites in the residue definition depends on a number of factors, and the decision on whether metabolites should be included is a very complex one and decisions have to be made on a case-by-case basis (FAO, 1997).

2.1.3 MAXIMUM RESIDUE LIMIT (MRL)

The MRL is defined as the maximum concentration of a residue, resulting from the officially authorized safe use of agricultural chemicals recommended to be legally permitted or recognized as acceptable in or on food, agricultural commodities, or animal feed. The concentration is expressed in milligrams per kilogram of the commodity. MRLs are based on long term feeding trials with at least two-disparate species taking into account the "No Observable Effect Level" for the most sensitive one. On the other hand, when several pesticides are metabolized from a compound, which itself is used as a pesticide (example: benomyl & carbendazim), and in addition, in some such cases, the toxicology is substantially different for the pesticide and its metabolite (e.g. dimethoate & omethoate), then whenever possible, the parent pesticide and its metabolite(s) which are also used as pesticides should be subject to separate MRLs (FAO, 1997).

Table 1: Pesticide classes and Their Use (after Ware, 1991).

Pesticide class	Function	Pesticide class	Function
Acaricide	Kills mites	Nematicide	Kills nematodes
Algicide	Kills algae	Ovicide	Destroys eggs
Avicide	Kills or repels birds	Pediculicide	Kills lice (head, body)
Bactericide	Kills bacteria	Piscicide	Kills fish
Fungicide	Kills fungi	Predicide	Kills predators (coyotes, usually)
Herbicide	Kills weeds	Rodenticide	Kills rodents
Insecticide	Kills insects	Silvicide	Kills trees and bush
Larvicide	Kills larvae (usually mosquito)	Slimicide	Kills slimes
Miticide	Kills mites	Termiticide	Kills termites
Molluscicide	Kills snails and slugs (may include oysters, clams, mussels)		

Table 2: Chemicals classes considered as pesticides not bearing the suffix`cide` (after Ware, 1991).

Pesticide Class	Function
Attractants	Attract insects
Chemosterilants	Sterilize insects or pest vertebrates (birds, and rodents)
Defoliants	Remove leaves
Desiccants	Speed drying of plants
Disinfectants	Destroy or inactivate harmful micro organisms
Feeding stimulants	Cause insects to feed more vigorously
Plant and insect growth regulators	Stimulate or retard growth of plants or insects
Pheromones	Attract insects or vertebrates
Repellants	Repel insects, mites, and ticks or pest vertebrates (dog, rabbits, deer, and birds)

Once an MRL is set, it is used as an indicator of Good Agricultural Practice (GAP) as stated by the National Residue Survey (NRS) in Australia. A commodity with a residue measurement above the MRL indicates that the commodity was not produced in compliance with GAP and cannot be legally sold. In Australia, no agricultural chemical is registered for use unless MRLs have been set for that use, or the chemical has been exempted from the need to set an MRL (where the chemical should not occur in food or the level of residue is considered to be of no toxicological significance). Registered uses and MRLs can both be reviewed after approval (Commonwealth of Australia, 1996). This is in line with the argument of Banks *et al.* (1990) who stated that acceptable levels of pesticide residues in plant and animal products are stipulated by legislation and excessive residues can lead to rejection of farm produce for sale, condemnation of products such as milk or meat, or quarantine restrictions being placed on livestock farms. They continue to say, that the MRL is not the safety limit and in practice it is usually a factor of 100 or more below any level, which could be a toxicological hazard when ingested regularly. MRLs are set on the basis of residue trials, which simulate conditions in the field. Generally, no MRLs are set for processed foods. For foods such as vegetables, fruits, meat and fish that undergo little processing before consumption, the MRL for the commodity can suffice (Australia New Zealand Food Authority (ANZFA), (1994). On the other hand, in normal practice, MRLs are not recommended for residues in agricultural commodities used primarily for human or veterinary drug or medicine production, since it is assumed that processing under good manufacturing practices will remove any residues, which might constitute a toxicological hazard to human health (Commonwealth Department of Human Services and Health, 1994). The same concept is applied for residues in agricultural products used primarily for fibre production, such as flax, cotton, hemp, wool etc. Also as a matter of policy MRLs are not recommended for residues in tobacco since the substance is considered dangerous regardless of the level of any additional compound.

From a public health viewpoint, MRLs need to be set for each chemical for the range of products on which that the Allowable (Acceptable) Daily Intake (ADI) is not exceeded for the majority of consumers (Commonwealth of Australia, 1996).

Although MRLs are not direct health measures, the toxicology of the chemical is taken into consideration when setting the MRL (ANZFA, 1994). The authors indicate that the MRL is not recommended and the use of a pesticide not approved where the resulting residues could possibly lead to intakes exceeding the ADI.

The Codex Maximum Residue Limit for Pesticide (MRLP) is the maximum concentration of a pesticide residue (expressed as mg/kg), recommended by the Codex Alimentarius Commission (Codex, 2000) to be legally permitted in or on food commodities and animal feeds. Foods derived from commodities that comply with the indicated MRLPs are intended to be toxicologically acceptable. That is, considerations of the various dietary residue intake estimates and determinations both at the national and international level in comparison with the ADI should indicate that foods complying with the MRPLs are safe for human consumption (Codex, 2000).

Codex MRLPs are primarily intended to apply in international trade and are derived from reviews conducted by the Joint Meeting on Pesticide Residues (JMPR) following: (a) review of residue data from supervised trials and supervised uses including those reflecting national GAP, and (b) toxicological assessment of the pesticide and its residue (Codex, 2000).

2.2 HISTORY OF PESTICIDES

The earliest record of any material being used as a pesticide is by Homer, The Greek poet, who referred to the burning of sulfur for fumigation of homes in about 1000 BC (Ware, 1983). The same author (Ware, 1983) stated that with the use of the arsenical pares green and kerosene emulsions as dormant sprays for deciduous fruit trees (1867- 1868), the scientific use of pesticides had begun.

Pyrethrum, lime and sulfur combinations, arsenic, mercuric chloride, and soaps were the materials found effective between 1800-1825. Between 1825 and 1850, quassia, phosphorous paste, and rotenone were employed (Ware, 1983).

The discovery of DDT in 1939 by the chemist Paul Muller marked the beginning of a widespread effort to investigate, develop, and manufacture new synthetic insecticides.

2.3 IMPORTANCE OF PESTICIDES

When millions of humans are killed or disabled annually from insect-borne diseases and crop losses from insect, diseases, weeds and rodents are estimated at $90 billion annually, it becomes obvious that control of various harmful organisms is vital for the future of agriculture, industry and human health. Pesticides thus become indispensable in feeding, clothing and protecting the world population (Ware, 1983).

As we know, plants are our main source of food. They compete with more than 80,000 plant diseases caused by viruses, bacteria, mycoplasma-like organisms, rickettsias, fungi, algae and parasitic higher plants. In addition to, approximately, 1800 weed species causing serious economic losses, about 1000 nematode species that cause crop damage, and 10,000 insect species add to the devastating loss of crops world wide (Ware, 1991). In the U.S.A. the crop losses from pests had doubled in the previous 35 years despite a tenfold increase in pesticide use as estimated by Van Emden and Peakall, 1996).

Pesticides are considered as an integral part of modern agriculture because they reduces labor, lower the cost of production, and reduce the risks of crop loss. The total of active ingredients used in the U.S. in 1989 was estimated at 1.1 billion pounds, valued at $7.23 billion at the retail level. Of this, the agricultural market consumed 75.3%, industry and governmental utilized 18.2%, while home and garden use up to 6.4% of the volume (Ware, 1991). The same author pointed out that several good examples of specific increases in yields resulting from use of insecticides were determined in 1976-78 by controlling insects in test plots in which the insects were allowed to feed and multiply un-controlled. From a single insect pest species, under severe conditions, each of the major crops suffered substantial losses: corn from corn borer, 24%; soybean from the Mexican bean beetle, 26%; wheat from wheat mite, 79%; cotton from bollworm complex, 79%; and potatoes from European corn borer, 53%. Lack of pesticide control lead to the famous potato famine of Ireland (1845 – 1851), which occurred as a result of a massive infection of potatoes by the late blight fungus (*Phytophthora infestans*) that resulted in the loss of about a million lives and huge migration of Irish people into the U.S.A.

Until 1995 in the field of public health; malaria affected more than 200 million people throughout the world. The annual death rate from this debilitating disease has been reduced from 6 million in 1939 to less than a million today through the use of insecticides. Similar progress has been made in controlling other important tropical diseases such as yellow fever, African sleeping sickness and chagas disease (Ware, 1991). The Panama Canal was abandoned in the 19th century by the French because more than 30,000 of the work force died from yellow fever.

2.4 CONSUMPTION OF PESTICIDES

Pesticides are used all over the world (Table 3). From the date in the table it is clear that there has been an increase in pesticide use all over the world between 1977 and 1984. However, the USSR reports the greatest increase in consumption that approached 53.5%. According to Ware (1983) the United States market is the largest representing 34 percent of the world total.

Developing countries still use organochlorine insecticides (Table 4). DDT and BHC still comprise over 50% of the pesticides used in India, and their uses are still increasing (Ramesh *et al.*, 1993). The same author stated that, in the late 1980's, 10,000 tons of DDT and 47,000 tons of BHC were used annually. DDT is still, however, widely used in less developed countries. When the last DDT manufacturing plant in the U.S was dismantled in 1983, it was sold to Indonesia, where it is currently manufacturing DDT (Muir, 1998).

Table 3: Consumption of pesticides by region by comparing the mean value in ton active ingredient per year for 1975-77 and 1982-84 (UNEP, 1991-92; Environmental data report) (After Van Emden and Peakall, 1996)

Region	1975-77	1982-84	% Increase
Africa	68,181	66,608	-2.3%
Asia	284,476	315,910	+11%
Europe	506,830	585,405	+8.6%
North America	529,194	484,052	-8.5%
Oceania	62,289	66,993	+7.6%
South America	108,324	99,350	-8.3%
USSR	348,767	535,400	+53.5 %
World	1908,059	2153,718	+12.9 %

Table 4: Metric tons of organochlorine insecticides used in the developing world (Data Country of Land ell Mills Market Research Limited) (After Van Emden and Peakall, 1996).

Country Middle East & Africa	Field application (1992)
Iran	111
Ivory Coast	87
Kenya	15
Morocco	0
Nigeria	93*
Sudan	125
Zimbabwe	42

* Data of 1989

2.5 RISKS POSED BY PESTICIDES

All pesticides are to a greater or lesser extent toxic to humans. There are no entirely safe pesticides. There are however, numerous safe handling practices that can minimize or remove the risk of poisoning and other harmful effects (Gerozisis and Ladlington, 1995). Those authors also stated that, the ways in which pesticides affect humans and other mammals are commonly referred to as "modes of action". The mode of action of a number of pesticides in use today are either not known or, in some instances are only partially understood. However, medical research does provide sufficient information to permit certain generalizations. Even though it may not be known exactly how a pesticide poisons the body in all cases, those who use pesticides should recognize the signs and symptoms resulting from such poisonings. Other workers stated that, some pesticides are much more toxic than others, and severe toxicity may result when only small amounts of a certain chemicals has been ingested (Ware, 1983). While with other compounds, no serious effects would result even after ingesting large quantities, some of the factors that influence this are related to the toxicity of the chemical, the dose of the chemical, especially concentration, length of exposure, and the route of entry to the body.

2.5.1 PESTICIDE POISONING IN HUMANS

As stated by Ware (1991), pesticides can affect humans either directly or indirectly.

A. Direct effect

Pesticides may enter the human body by inhalation, ingestion or be absorbed through the skin. Two types of poisoning by pesticide may occur:

1. Acute poisoning: where a single dose or intake of the poison causes poisonous symptoms ranging from mild to severe and perhaps death.
2. Chronic poisonings where several small doses or intake of the poison accumulate in the body over a period of time to cause poisoning symptoms and possibly death.

B. Indirect or delayed effect

Sometimes referred to as "long term effect" these effects represent a form of chronic toxicity in which there can be a significant time delay between the last exposure and the development of symptoms. Examples includes pesticides induced: teratogenicity, neurogenicity, mutagenicity, and carcinogenicity.

Ingestion (oral absorption) is much less common and is usually a result of the disregard for pesticide risk. Inhalation is the least common route of entry except with fumigants and when handling highly volatile and concentrated chemicals in confined spaces.

Dermal (skin) absorption

Is the most important entry route of pesticides and is often not noticed until symptoms develop. It can occur during handling of concentrated pesticides and during application, particularly if protective clothing is not worn. Dermal absorption is also more likely to occur during hot weather when the skin is wet with perspiration, and through cut and abrasions (Banks *et al.*, 1990). This is in line with Mathews and Hislop's (1993) argument who showed that in plant protection activities, the main risk of exposure is through the skin.

Operator risk

Clearly, constant occupational contact with pesticides may harm the health of the operator. Such risks can be avoided by choosing pesticides carefully, reading and following label directions, wearing proper protective clothing and equipment, using well maintained equipment, having regular medical checks, adopting safety-conscious work habits, and having some knowledge about pesticides and their poisoning characteristics.

Public risk

Most of the work of urban pest control involves application of pesticides in and around buildings where people work and live. Operators must have a sound understanding of the potential for poisoning of the entire chemical they apply. They should apply chemicals with attention of minimizing the likelihood of human contact. They should be especially aware of the somewhat unpredictable behavior of young children.

Fatal human poisoning by pesticides is uncommon in the U.S. and is mostly due to accident, suicide or on rare occasions, to crime. Fatalities represent only a small fraction (2.6%) of all reported cases of pesticide poisoning. (Ware, 1991)

Risk to non-target organisms

Fish (kept indoors or out), cats, dogs, birds, beneficial insects (especially bees), and other species found in domestic surroundings can be affected by urban application of pest control measures. Careful application of selected pesticides can reduce the risk of poisoning domestic pets.

2.5.2 IMPACT OF AGROCHEMICALS ON THE ENVIRONMENT

In recent years the community has become very conscious of the effects of chemical residues on the environment. Some of these effects are direct others are cumulative. Some are well documented but most are not clearly understood because of the lack of accurate objective data and the complexity of interacting factors common to many environmental problems.

In 1983, Ware raise the questions "what is the effect on the environment, human health, wildlife, beneficial insects and plant and safety of our food if we continue to use pesticides at the current rate?" and "what are the magnitudes of the penalties if we continue to depend on pesticide as the single answer to pest control?" However, in different parts of the world that have started to think about alternative agriculture and low pesticides inputs, Matthew and Hislop (1993) argued that the increase in agricultural production in Europe in the last decades has caused serious environmental problems. As a result, the Danish Parliament decided that the use of agrochemicals should be reduced by 25% Matthew and Hislop (1993). A further reduction of 25% was envisaged by 1997. The Dutch farmers' organization had predicted crop losses up to 50% as a result of a government plans to reduce pesticide usage (Matthews and Hislop, 1993). This was demonstrated in USA where the pressure to reduce pesticide inputs is growing and an analysis of the possible environmental and economic impact of such reductions suggest that considerable benefits might occur with only negligible increase in the cost of food (Pimental *et al.*, 1991). The same case was found in Europe where the idea for low input on alternative agriculture has become more popular as stated by Matthew and Hislop (1993). According to Van Emden and Peakall (1996), pesticides were ranked third after the heavy metals and petroleum hydrocarbons with respect to environmental considerations.

An indirect effect of pesticides is through their accumulation in the food chain. As an example, in an extensive analytical study on fish from the Great Lakes system (U.S.A.), nearly 500 different man-made chemicals have been identified in their flesh (Van Emden and Peakall, 1996).

The earlier use of chlorinated hydrocarbons still has its effect on the environment where some scientist claimed that DDT and PCBs can act as weak estrogens and have been correlated with an increasing incidence of breast cancer.

The leaching of pesticides into ground water has also received great attention. According to Biologische Bundesantalf (BBA) in Germany, the residue issue in ground water can only be solved in the long term by prohibiting the use of all products that can leach into the ground water (Matthew and Hislop, 1993). In 1989, the EPA (U.S.A.) introduced a tiered plan to protect ground water from leaching pesticides.

Drinking water was considered equally where Matthew and Hislop (1993) concluded that transportation of hazardous materials, including pesticides, might be prohibited through drinking water catchment areas. German authorities established a safety belt of 20 m around treated tree crops that border open water sources. Transportation of hazardous material including agrochemicals through drinking water collection areas is also prohibited. However many countries still consider environmental management to be a luxury. This was illustrated by the example that older chemicals are often used in developing countries. Such chemicals are relatively inexpensive; they are no longer patent protected and can be manufactured in developing countries, often in the absence of safety standards as was clearly shown at Bhopal in India. In addition, developed countries have been accused of dumping their banned chemicals on developing countries. For example, in 1990 over US$12 million of pesticides that were banned or had their registrations cancelled were shipped from US ports (Smith and Beckman, 1991). To prevent such cases, US exporters must now inform foreign buyers of the known hazards of these products as well as of any changes in the regulatory status of these chemicals in the USA (USAID, 1990a,b). Similarly, the FAO code recommends that “prior informed consent” should be obtained from the government of the country of destination before the shipping of pesticides. Also internal regulation of many countries such as the U.A.E. require registration certificates from the country of origin of the pesticide in order to accept it for use (Federal Law, 1992). However, some authors claim that it is a political decision for every country as to what level risks are considered acceptable under specific social, economic, and environmental conditions (Matthews and Hislop, 1993).

Also at the core of this problem is the misuse of all pesticides with special reference to persistent compounds. The misuse of pesticides can be defined by the following processes: non-respect of the dose, non-selective application, lack of care in the selection of the chemical, safety period or with- holding periods that have not been observed, and inappropriate timing of application. With restricted, careful and selective application of pesticides such damage can be greatly minimized.

To prevent unnecessary exposure to pesticides, the EPA now requires safe waiting intervals between application of all pesticides and worker reentry into treated fields. The waiting intervals established by the EPA according to Ware (1991) are a 48 hours minimum for pesticides from category 1, 24 h minimum for pesticides from category 2, and until sprays have dried or dusts have settled for pesticides from categories 3 and 4.

If the worker must enter the field earlier than the stated waiting intervals, they must wear protective clothing. However, when poisoning occurs the first aid treatment received during the first 2-3 minutes following the poisoning accident may make the difference between the life and death.

2.5.3 PESTICIDE RESIDUES ON FOOD

Worldwide and specially in developing countries, the public are worried about the quantity of agrochemicals used and their possible effects on human, animal and other non-target species. Among these, the most important issue is that of pesticide residues on food as declared by Mathews and Hislop (1993) who stated that, one of the main issues facing current and future direction of U.S. agriculture is the environment. However, ground water contamination and pesticides residues in food are at the top of the list.

The first law controlling pesticides residues on food in USA was established in 1938 (Pimentel, 1997). By 1954, the Miller Amendment of the Food, Drugs and Cosmetics Act (AFDCA) was established to control the legal pesticide residues (tolerances), which may appear in and on food. In 1958, the Delaney amendment was passed declaring that no additive could be considered safe if it caused cancer when ingested by people or animals. Pesticides that concentrated when food was processed were considered food additives subject to the Delaney amendment (Pimentel, 1997). In legislating for safe pesticide use, it is common to refer to "Good Agricultural Practice"(GAP), which in essence relates to compliance with pesticide label instructions so that maximum residue limits are not exceeded (Bates, 1990). However, excessive or illegal residues can occur from the use of unregistered or inappropriate pesticides, careless or inefficient application with faulty equipment, drift on to adjacent fields, spraying too close to harvest, or grazing (Banks *et al.*, 1990).

The concept of withholding period (safety period) in pesticide application was introduced as a practical means to ensure that pesticides residues don't exceed the maximum residue limit at the time of food sale or consumption.

Banks *et al.* (1990) stated that some pesticides are rapidly inactivated after applications where as others (or their by-products) can persist for years in a biologically active form. This residual contamination can affect human health, livestock, and subsequent crop growth and cause environmental pollution. For example DDT, DDD and DDE are persistent chlorinated hydrocarbon agrochemicals, However, DDT has not been used on livestock since the early 1970's and is no longer used as a pesticide in most Australian states (it has not been used for some years), though is still ingested with soil by grazing stock.

Of the organochlorine residues found in beef between 1991 and 1992, 7% of sheep fat samples were found to contain DDT residues (Commonwealth of Australia, 1996).

In Australia the role of the national residue survey is to monitor and assess the level of chemical residues in raw agricultural commodities produced by Australian agriculture. Their main activities are to assure confidence in the quality and safety of those products to the consumer, and identification of chemical residue problems, their causes and possible solutions. In addition they provide scientific advice on chemical residue problems, which contribute to the development of the national chemical residue and food safety policy (Commonwealth of Australia, 1996). Also chemical residue monitoring is an important part of any strategy to minimize unwanted chemicals in food (Commonwealth of Australia, 1996).

The fruit and vegetables survey conducted under the National Residue Survey (NRS) in Australia, during 1991-92, included 3877 individual samples (Table 5).

As shown in Table 5, 2014 samples were taken in 1991, (456 or 23%) of these samples were found with detectable residues; eight (or 0.4%) of samples were above the MRL and/or the maximum permitted concentration (MPC) standards. Also, 1863 samples were taken in 1992; of which 1290 (or 69.2%) had detectable residues and 16 samples (or 0.9%) were above the MRL and MPC standards (Commonwealth of Australia, 1996). In another survey 809 (<1%) of samples from a total of 95,185 where found to contain residues above the MRL. Most samples analyzed (87%) had no detectable residues, even at the very low levels of detection, which are currently possible (Commonwealth of Australia, 1996). Table (6) shows the MRL values on fruits and vegetables for different chemicals as set by Commonwealth Department of Human Services and Health (CDHSH) of Australia.

All samples from the tomato crops surveyed for pesticide residues by the Commonwealth of Australia in 1996 for fungicides (Benomyl and dithiocarbamates) and insecticides (carbamates, organochlorines, and organophosphates) were found to be in compliance with the Australian standards.

Table 5: Analysis results of fruits and vegetables surveyed by the National Residue Survey (NRS) in Australia during 1991-92.

Year	No. Of Samples	Samples with Residues	Violated samples	Percentage
1991	2014	23	8	0.4
1992	1863	69	16	0.9

Pesticides are probably the most regulated chemicals products used in the U.S.A. Several major official organizations regulate the use of pesticides. These include the Environmental Protection Agency (EPA), the Food and Drug Administration (FDA), and the U.S. Department of Agriculture (USDA). Other bodies such as the Environmental Working Group (EWG) are also interested in pesticide residues on food. The regulations of pesticide use and pesticide residues on or in food are intended to protect human health. For example, the "No Toxic Effect Level" (NOEL) becomes the basis for the permitted residue limit.

The regulations set the permitted residue level at a level that is from 10 to 100 times lower than the NOEL. Furthermore, if a pesticide is tested, and a NOEL cannot be determined, then it is unlikely to be permitted for use on food crops. This ensures that if a person, (child or adult) eats a larger than normal amounts of a particular food, or several different foods with the same or similar pesticide residues, they will still not reach the level of exposure required for a toxic effect to occur, even if they are more sensitive than the average for the general population.

In a study conducted by the EWG (1995a) on domestic and regional food crops during 1992-1993, it was determined that one-third to one-half of all the pesticide residues detected on some crops were illegal. This included 51.7% of the detected residues in apple juice, 50.6% on green peas, 28.4% on pineapples, 26.4% on pears, and 22.6% on carrots. These results point toward a potentially high level of illegal pesticide use on these crops that is escaping detection by the state enforcement authorities and the FDA.

Many of the pesticides that have been banned or restricted for health reasons have been found illegally on different foods. This includes captan, a probable human carcinogen banned on 30 crops by the EPA for health reasons, found illegally on 14 of these crops. Chlorpyrifos, (potent neurotoxin) heavily used in schools and homes but restricted to use on certain foods, found illegally on 16 crops. Endosulfan, an organochlorine compound that mimics the female hormones estrogen, has been found illegally on 10 crops (EWG 1995a).

Important crops from major suppliers have even higher violation rates, including green peas from Guatemala with a 40.8% violation rate, strawberries from Mexico at 18.4%, green onions from the United States at 16.7%, head lettuce from Mexico at 15.6%, carrots from Mexico at 12.3%, and tomatoes from the U.S. at 9.4% (EWG1995a).

The results obtained from the EWG who conducted the above study, contradicts those obtained by FDA regarding the detection rate of pesticide residues on some crops. For examples, the FDA reports 4.0% of imports with illegal pesticides, while the EWG records indicated the rate to be 7.4%. The actual violation rate of 24.8% was reported by EWG on products from Guatemala, while the corresponding rate indicated by the FDA was is 13.8%.

They claimed that these problems with the FDA pesticide monitoring program are not new. Since 1980, the U.S. General According Office (GAO) has published 22 reports detailing the shortcomings of the FDA pesticide-monitoring program. They continue to report that this process fails to work effectively or efficiently and that it routinely allows shipments of produce with illegal pesticides to be unwittingly purchased and eaten (EWG1995a).

According to the data from the FDA and EPA, the EWG reported on the total amount of pesticide residues found in 42 fruits and vegetables. They found that more than half of the total dietary risk from pesticides in these foods was concentrated in just twelve crops, including strawberries, bell peppers, spinach, cherries, celery, apples, and cucumbers. The EPA classified the pesticides that were found in these foods as probable human carcinogens, nervous system poisons, and endocrine system disrupters Wiles *et al.* (1995).

Table 6: MRL standard maximum residue limits in food and animal foodstuffs. (Australia) (Commonwealth Department of Human Services and Health, 1994)

Compound	Residue	Food	MRL (mg/kg)
Benalaxyl	Benalaxyl	Fruiting vegetables (Cucurbits)	0.2
Benomyl	Residue arising from the use of benomyl is covered by MRLs for carbendazim. Carbendazim residue: sum of carbendazim and 2-amino-benzimidazole, expressed as carbendazim.	Fruiting vegetables (cucurbits)	2
Bromopropylate	Bromopropylate	Pome fruits Stone fruits	5 5
Chlorpyrifos	Chlorpyrifos	Tomato Vegetables (except asparagus, brassica vegetables, cassava, potato, tomato)	0.5 0.01
Dimethoate	Sum of dimethoate and omethoate, expressed as dimethoate	Tomato Vegetables (except lupine [dry], peppers sweet, tomato)	1 2
Fenbutatin-oxide	Bis [tris (2-methyl-2-phenyl propyl) tin]	Berries and other small fruits	1
Mancozeb	See dithiocarbamates. Dithiocarbamates (except propineb) Determined and expressed as disulfide.	Fruiting, vegetables, (cucurbits) Tomato	1 3
Oxadixyl	Oxadixyl	Fruiting vegetables, Cucurbits	0.5
Tetradifon	Tetradifon	Vegetables	5
Thiram	See dithiocarbamates Dithiocarbamates (except propineb)	Fruiting vegetables, cucurbits Tomato	7 1 3
Ziram	Determined and expressed as carbon disulfide	Vegetable	7

One million American children aged 5 and under are exposed daily to unsafe levels of organophosphate (OP) insecticides that exceed the EPA safety standards, (EWG, 1998). The study found that most of the risk to children comes from five chemicals: methyl parathion, dimethoate, chlorpyrifos, pirimiphos Methyl and azinphos-methyl. For infants six to twelve month of age, commercial baby food is the dominant source of unsafe level of organophosphates (OP's). According to this study, 13% of the apples, 7.5% of pears and 5% of grapes samples in the U.S. food supply expose the young children eating these fruits to unsafe levels of OP's. The major culprits are peaches, applesauce, popcorn, corn chips, and apple juice. The reference doses used in this study were the values adopted by the EPA as per the requirements of the Food Quality Protection Act (FQPA). However, the FQPA requires EPA to act to protect infant and child health, even in the absence of total scientific certainty regarding the toxicity or exposure of pesticides to the fetus, infants or young children.

Sixteen pesticides were detected in 8 baby foods made by the three major baby food producers that account for 96% of all sales, including three probable human carcinogens, five possible human carcinogens, eight neurotoxins, five pesticides that disrupt the normal functioning of the hormone system, and five pesticides that are categorized as oral toxicity category one, the most toxic designation (EWG, 1995b). The same study found that fruits contained more pesticides and higher levels of residues than vegetables.

According to the EPA (1995), surface cleaning (rinsing and scrubbing) of fruits and vegetables will not remove pesticide residues that are absorbed into the growing fruit or vegetable before harvest.

The annual report by the Working Party on Pesticide Residues (WPPR) showed that (2-4 Compounds) were found in 4 of the 60 tomato products assessed. Among these was metalaxyl , which was found in 2 samples from Spain in the range at 0.05 - 0.08 mg/kg. Thirty seven pesticides were actively sought but not found at or above their reporting limit, among this group were included chlorothalonil and chlorpyrifos (Health & Safety Executive, 1997)

The same report shows that residues of only one compound (carbendazim at 0.1 mg/kg) of the 54 pesticides examined was detected in wide range of tomato products (60 samples). Among those examined were chlorothalonil, chlorpyrifos, diazinon, dimethoate and metalaxyl. (Health & Safety Executive, 1997).

In an earlier survey of cucumbers carried out in 1993 by WPPR (7%) of the 96 samples analyzed contained carbendazim above the reporting limit of 0.2 mg/kg up to 0.9 mg/kg and 89 (93%) of samples contained residues of inorganic bromide above the reporting limit of 0.05 mg/kg up to 124 mg/kg. (Health & Safety Executive, 1997).

Data collected by the Pesticide Data Program (PDP), 2000 presented a good comparator for the relative amounts and toxicities of pesticide residues in tomato from different countries .In their judgment, values greater than 100 on the Toxicity Index (TI) scale show comparatively high pesticide contamination, and values less than 10 indicate that those foods are comparatively quite "clean" (values in the range from 10 to 100 represent increasing degrees from "low" to "moderate" levels of pesticide contamination). The data shows that for the year 1997 samples, from Canada, had total Toxicity Index (TI) values of 25.7 and only four pesticides were detected. While in the 1998 samples for the same country the total TI values dropped to 11.6, nine pesticides were detected including Diazinon which represented 25.8% of the total pesticide toxicity and Chlorothalonil which represented 0.4%. While in contrast, in Mexico in 1996 the contamination levels were higher with a total TI value of 292.2 and 13 pesticides detected including Chlorpyrifos representing 62.5% of the total TI for all pesticides. While in 1997, the total TI values increased to 407.5 and the number of pesticides detected increased to 26 of which Chlorpyrifos represented 42.8% of the total pesticide toxicity, while Chlorothalonil and Diazinon were found in trace amounts. Furthermore in 1998 the total TI values increased again to 472.4 and the number of pesticides detected increased to 27. The same study showed that for the U.S. samples the total TI value was 218.6 with 20 pesticides detected (1996). Whereas in 1997 samples for U.S., the total TI value had dropped slightly to 205.0 while the number of pesticides detected rose to 27. In 1998 samples for the same country showed a dramatic drop in the total TI value to 116.3 while the number of pesticides detected were similar at 26 (Groth *et.al,* 2000).

The same study found that "In general, processed food have less pesticides than fresh foods" (Groth et.al, 2000).

According to the study done by the Michigan Food Monitoring Program (1992), 23 cucumber samples contained pesticides of the 42 samples screened, three pesticides were detected; Carbofuran was detected in 14% of the samples at the range of (0.007-0.18 ppm), while Chlorothalonil was detected in 24% of the samples at the range of (0.08-0.40 ppm) which is below the Australian and the Codex Alimentarius MRL (5.0 ppm), and Dieldrin found in 19% of the samples at the range of (0.02-0.07 ppm) which is also below the Australian and the Codex Alimentarius MRL (0.1 ppm).

Moreover, in another study by the same organization (Michigan Food Monitoring Program, 1996) 12 of 20 (60%) of cucumber samples from USA market had one or more pesticides detected in them, for example Metalaxyl was detected in 25% of the samples at the range of (1.0 0.14 ppm) which is below the Codex MRL of 0.5 ppm and the Australian MRL of 0.2 ppm. Also Chlorothalonil was detected in 5% of the samples at the level of 1.5 ppm, which is below the Codex and the Australian MRLs (5.0 ppm).

The annual report by the Health & Safety Executive, 1999) showed that 25% of the food samples analyzed contained pesticides residues at levels below the maximum residue levels (MRLs) and 1.4% of samples exceeded the (MRLs). The report indicated that in the year 1995, 3230 samples were analyzed, 31% of these samples contained residues and, 1% of the samples exceeded the MRLs. Similarly, in 1996, 2263 samples were tested of which 34% contained residues, and 1% exceeded the MRLs. While in 1997 and 1998 the number of samples analyzed were 1878 and 2200 respectively, of which 29% and 25% contained pesticides residues and 1% and 1.4% exceeded the MRLs.

According the United States Department of Agriculture (USDA 1996, 1997, 1998 & 2001), for the calendar years 1996-1999 (Table 7) , 1819 tomato samples from the USA were screened for Chlorothalonil which was detected in 160 samples

(8.8%) within the range of (0.005 2.4 ppm) which is below the Codex (MRL 5 ppm).

The same table shows that 1318 samples of tomatoes screened for Chlorpyrifos in the same period, only 135 (10.2%) displayed detectable levels of this compound within the range of 0.005-0.57 ppm.This indicates that some samples had exceeded the Codex MRL 0.5 ppm.

The same samples (1318) were screened for Diazinon during the same period, of which, only 12 samples (0.9%) were contaminated within the range of 0.003-0.090 ppm, which is well below the Codex MRL 0.5 ppm.

In addition , 1960 samples were screened for Dimethoate only 4 samples (0.2%) displaying detectable levels of this compound within the range of 0.1-0.4 ppm which is below the Codex MRL 1 ppm.

Furthermore, 451 tomato samples were screened for Metalaxyl, only 2 samples (0.4%) displaying detectable levels within the range of (0.005-0.026 ppm) which is below the Codex MRL 0.5 ppm.

From the same study (USDA, 2001) between 729 and 730 cucumber samples were tested for Chlorothalonil, Chlorpyrifos, Diazinon and Dimethoate with 180 samples tested for Metalaxyl (Table 8).

Only in the case of Dimethoate did any of the detections approach or exceed (though only slightly) the CODEX MRL, for the remaining compounds, all detections were below the CODEX MRL.

Table 7: Distribution of Residues by Pesticide in Tomatoes for the years 1996-1999. (USDA, 1996, 1997, 1998, 2001)

#	YEAR	PESTICIDE	TOTAL SAMPLES SCREENED	SAMPLES WITH DETECTION	% OF SAMPLES WITH DETECTION	RANGE OF VALUES DETECTED ppm	CODEX MRL ppm
1	1996	Chlorothalonil	174	20	11.5	0.005-2.4	5
	1997	Chlorothalonil	708	54	7.6	0.008-1.7	5
	1998	Chlorothalonil	672	63	9.4	0.008-0.57	5
	1999	Chlorothalonil	265	23	8.7	0.008-0.14	5
2	1996	Chlorpyrifos	174	17	9.8	0.005-0.11	0.5
	1997	Chlorpyrifos	108	0			
	1998	Chlorpyrifos	672	63	9.4	0.008-0.57	0.5
	1999	Chlorpyrifos	364	55	15.1	0.005-0.094	0.5
3	1996	Diazinon	174	0			
	1997	Diazinon	707	2	0.3	0.003-0.015	0.5
	1998	Diazinon	717	8	1.1	0.003-0.090	0.5
	1999	Diazinon	364	2	0.5	0.003	0.5
4	1996	Dimethoate	174	0			
	1997	Dimethoate	705	1	0.1	0.005	1.0
	1998	Dimethoate	717	3	0.4	0.003	1.0
	1999	Dimethoate	364	0			1.0
5	1996	Metalaxyl	27	0			
	1997	Metalaxyl	108	1	0.9	0.026	0.5
	1998	Metalaxyl	323	1	0.3	0.005	0.5

Table 8: Distribution of Residues by Pesticide in Cucumbers for the year 1999 (USDA, 2001)

#	PESTICIDE	TOTAL SAMPLES SCREENED	SAMPLES WITH DETECTION	% OF SAMPLES WITH DETECTION	RANGE OF VALUES DETECTED ppm	CODEX MRLs ppm
1	Chlorothalonil	730	33	4.5	0.007-0.091	5
2	Chlorpyrifos	730	9	1.2	0.007-0.094	
3	Diazinon	730	3	0.4	0.011-0.023	0.1
4	Dimethoate	729	100	13.7	0.003-0.11	0.1
5	Metalaxyl	180	0	--	--	0.5

From 1990 to 1998 a total of 3325 food samples were tested by the Connecticut Agricultural Experiment station for pesticides residues (Walter *et al.* 1999). The results (Table 9) indicated that 2150 (64.71%) samples were free from residues, while 1136 (34.1%) samples contained residues, 6 samples (0.2 %) were over the U.S. Environmental Protection Agency (EPA) tolerances and 33 samples (1.0 %) contained residues for which there are no EPA tolerances.

From the 18th and the 19th (Australian & Newzeland, 2001), as shown in Tables (10,11,12 and 13). Pesticides maximum contaminant levels (mg/kg) in fruits and vegetables sorted by Chlorothalonil, Chlorpyrifos, Dimethoate and Diazinon, were below the Australian Maximum Residues Levels (MRL), except that for Chlorpyrifos which was found above the Australian MRL in Grapes at 0.1 mg/kg in the 19th and at 0.03 mg/kg in the 18th (Australian MRL = 0.01mg/kg). In addition, Chlorpyrifos was found in the lettuce in the 18th at 0.020 mg/kg (Australian MRL 0.01 mg/kg), also was in eggplant in the 18th at the same level of the Australian MRL, which is 0.01 mg/kg.

Table 9: Nine year summary of all market-basket samples tested in Connecticut (USA), including organic and processed food samples. (Walter *et al.* 1999)

Year	Total Samples Tested	Samples With No Residues	Samples With Residues Within EPA Tolerances	Samples With Residues Over EPA Tolerances	Samples With Residues With No EPA Tolerances
1990	418	186	230	0	2
1991	285	190	94	0	1
1992	273	179	89	1	4
1993	441	305	128	3	5
1994	545	414	125	1	5
1995	444	307	129	0	8
1996	327	188	134	1	4
1997	412	266	144	0	2
1998	180	115	63	0	2
Total	3325	2150	1136	6	33

Table 10: Chlorothalonil contaminant levels (mg/kg) in fruits and vegetables sorted by pesticide (19th ATDs) (ANZFA, 2001).

Survey	Food	No Of Samples	Maximum Contamination Level mg/kg	Australian MRLs Mg/kg
18th	Eggplant	21	0.010	5
	Lettuce	28	1.160	7
	Plums	21	0.040	10
	Tomatoes, dried, loose	9	0.010	10
19th	Capsicum	21	0.020	5
	Pears, washed	21	0.020	--
	Tomatoes	21	0.010	10

Table 11: Chlorpyrifos contaminant levels (mg/kg) in fruits and vegetables sorted by pesticide (19th ATDs) (ANZFA, 2001).

Sarvey	Food Type	No Of Samples	Maximum Contamination Level mg/kg	Australian MRLs mg/kg
18th	Apples	28	0.050	0.2
	Avocado	9	0.010	0.5
	Broccoli	20	0.070	0.5
	Eggplant	21	0.010	0.01
	Grapes	21	0.030	0.01
	Pears	21	0.040	0.2
	Plums	21	0.010	1.0
19th	Apples, unwashed	21	0.090	0.2
	Apples, washed	21	0.170	0.2
	Grapes, unwashed	18	0.100	0.01
	Lettuce	27	0.020	0.01
	Pears, unwashed	21	0.060	0.2
	Pears, washed	21	0.030	0.2

Table 12: Dimethoate contaminant levels (mg/kg) in fruits and vegetables sorted by pesticide (19th ATDs) (ANZFA, 2001).

Survey	Food	No Of Samples	Maximum Contamination Level mg/kg	Australian MRLs mg/kg
18th	Apples	28	0.110	2.0
	Avocado	9	0.010	2.0
	Bananas	9	0.050	2.0
	Beans, green	21	0.020	2.0
	Cucumber	21	0.110	2.0
	Eggplant	21	0.080	2.0
	Grapes	21	0.120	2.0
	Lettuce	28	1.630	2.0
	Mandarins	21	0.020	2.0
	Pawpaw	9	0.040	2.0
	Pears	21	0.350	2.0
	Plums	21	0.070	2.0
	Strawberries	21	0.130	5.0
	Tomatoes, dried, loose	9	0.020	1.0
19th	Capsicum	21	0.030	1.0
	Lettuce	27	0.050	2.0

Table 13: Diazinon contaminant levels (mg/kg) in fruits and vegetables sorted by pesticide (19th ATDs) (ANZFA, 2001).

Survey	Food	No Of Samples	Contamination Level mg/kg	Australian MRLs mg/kg
19th	Apples	28	0.060	0.5

Study of Pesticide Residues in the United Arab Emirates (U.A.E.)

An environmental terrestrial study, sponsored by the Abu Dhabi government, was conducted for one season (1996) in two agricultural areas in the Abu Dhabi Emirate (Al Ain & Liwa). The study title was "Pesticide, Nutrient, and Toxic Metals concentration in Agricultural Soil, Water, and Biota in Abu Dhabi Emirate" (ERWDA, 1997)

In domestic tomatoes from Al Ain, 94% of the samples were found to contain residues of at least one pesticide. Organophosphate and organochlorine compounds were detected in the samples. Which were collected directly from the field (unwashed). The most frequently detected pesticide residue was Lindane followed by ethyl parathion and then DDT. Other pesticides residues detected were BHC and its four isomers, heptachlor, chlorpyrifos, dimethoate, kelthane and endosulfan. Dimethoate and kelthane were detected only in one sample. The same pesticides with the exception of dimethoate, heptachlor, and two isomers of BHC were also found in Liwa on tomato and onion. Aldrin was not detected in Al Ain, samples although it found only in one sample from Liwa.

DDT was banned in U.A.E in 1971 and its detection along with its breakdown products in samples of biota, soil, and water is considered alarming. However, this study was considered preliminary and other detailed studies are required in order to draw more accurate conclusions. In the final report of the study the authors (ERWDA, 1997) claimed that the MRLs for pesticides of fruit and vegetables were not available. This makes it difficult to conclude to what extent these biota samples were contaminated in terms of risk to human health. The presence of trace amount of a pesticide does not necessarily mean that the product is unfit for human consumption. So, while pesticides may be found in many products, the level at which they are present is of importance.

The fact that pesticide residues are found in samples is only due to the significant advances in analytical chemistry. The tests are now so sensitive that the detection level that can easily be reached is equivalent to detecting one teaspoon of salt in one million gallons of water. Levels even lower than that can sometimes be detected.

2.6 THE ROLE OF INTERNATIONAL ORGANIZATIONS

The Food and Agricultural Organization (FAO) and World Health Organization (WHO) have paid attention to the issue of pesticide residues in food over the last 32 years. This is done through an expert body administered jointly by the

FAO and the WHO known as the " Joint Meeting on Pesticide Residues" (JMPR). The JMPR evaluates pesticide residue and toxicology data for estimation of MRLs and ADIs. It is composed of two groups, the FAO panel on pesticide residues in food and the environment, which determines MRLs and the WHO committee Assessment Group, which estimates ADIs and identifies risks to organisms in the environment (FAO, 1997). The role of the JMPR is to evaluate pesticides in order to estimate the maximum residue levels in food and feeds that are likely to result from legally permitted uses of pesticides when following GAP These estimates are the basis for establishing international MRLs in food and feed commodities moving in international trade.

2.6.1 EVALUATION PROCESS

Before establishing MRLs, there is considerable work done by the JMPR. This includes reviewing pesticide toxicology and related data and estimating the No Observed Adverse Effect Levels (NOAELs) of pesticides and ADIs of their residues in food for humans. They also estimate the acute reference dose (acute RfD) and characterize other toxicological criteria such as non-dietary exposures (FAO, 1997).

The physical and chemical properties of the active ingredient, the metabolism and degradation of the compound in animals, plants, soil and water is studied to determine the composition and distribution of residues. Based on this information, and taking into account the available analytical methodology for estimating MRLs and Supervised Trial Median Residue value (STMRs) of pesticides in food and feed commodities as well as the toxicological significance of metabolites and degradation products, the definition of residues for enforcement purposes and for dietary intake calculations are recommended (FAO, 1997).

Pesticide residue measurements contribute to our understanding of good agricultural practices as well as the safety of the food supply. For example the EPA uses residue estimates in its pesticide risk assessment, which contribute to the regulation of pesticides. Also to reduce risk from pesticides, residue estimates can be used to identify priorities for development of alternative pest control practices.

In a study conducted by Food and Drug Administration Pesticide Program (FDAPP) during 1997 for residue monitoring on raw agricultural products, 66% of both domestic and import samples were reported to be residue free. Only 1.2% of domestic and 1.6% of imported samples had residue levels, which were considered to violate the minimum levels set for the USA (U.S.F.D.A, 1998).

To examine chronic dietary risks from pesticide residues, the average residue and pesticide residue dietary intake indicators are estimated for each of the 50 pesticides on 10 fresh fruit and vegetables monitored under the 1992 Agricultural Marketing Service Pesticide Data Program AMSPDP (Anderson, 1997).

During the same year, the AMSPDP (in the USA) measured residues on samples of imported and domestic commodities including apples, bananas, celery, green beans, grapefruit, grapes, lettuce, oranges, peaches, and potatoes. These agricultural commodities were selected according to their level of consumption. These commodities were screened for 14 fungicides, six herbicides, and 30 insecticides.

The FDA also measures residues of pesticides on total dietary intake as well as on commodities directly through the Regulatory Monitoring Program (FDA-RMP), which is focused on enforcing tolerances (Anderson, 1997).

2.7 INTEGRATED PEST MANAGEMENT (IPM) IN RELATION TO PESTICIDE USE

The aim of IPM is to manage pest populations rather than to eradicate them and to do this in a way, which is least disruptive to the agro-ecosystem and ecology of the area. In other words to give the beneficial organisms a chance to contribute fully towards pest management and to use other cultural methods to assist with the management of crop pests.

An essential part of the IPM concept is that a pesticide should only be used when absolutely necessary (setting threshold levels) to prevent economic injury. It must be economically justifiable and the chemical used should be selective, of short persistence, low toxicity, have low vapour pressure, and socially acceptable. IPM is based on the planned and rational use of all pest control strategies rather than the sole reliance on chemical pesticides.

According to Banks *et al.* (1990), there are four essential steps in developing an IPM program for plant protection:

a. An understanding of pest biology and ecology is required.
b. Target definition and setting of economic injury levels must be performed.
c. Pest population monitoring must be conducted.
d. Selection of appropriate control strategies is required.

The target for the application of any pesticide may be defined as the best time and place to spray such agrochemical to achieve adequate control of the target organism.

Tweedy *et al.* (1991) showed an example of the use of careful pest monitoring and control is the processing carrot IPM system, which was developed by the Texas Agricultural Experiment station and provided to producers. In the first year (1988), insecticide use was reduced by 66% without loss in yield and quality. The same authors showed another example of an IPM program introduced by the Cooperative Extension Service for cotton, sorghum, and peanuts in mid-seventies. Before the introduction of the program the insecticide use on cotton, sorghum and peanuts was 73.4, 5.7 and 6.0 million pounds, respectively. By the early 80s, after 10 years of intensive educational work by the Cooperative Extension Service, insecticide use dropped to 16.9, 2.5, and 1.0 million pounds, respectively. A fresh market cabbage IPM program using similar methodology, showed that insecticide use was reduced by 44% (Tweedy *et al.*, 1991).

Van Emden and Peakall (1996) stated that resistance to pesticides is the principal driving force behind the introduction of the IPM concept in developed countries. They argue that public pressure based on environmental and health concerns is influencing both pesticide legislation and producers attitudes in the form of adoption of IPM. Some scientist claimed that IPM offers the most realistic possibilities for reducing and or eliminating residues of pesticides on food crops

(Tweedy *et al.* 1991). Taking into consideration these examples of adoption, we can say that IPM has the ability to reduce the levels of pesticide residues in food. This is supported by the idea of Frisbie and Magaro (after Tweedy *et al.* 1991) who pointed out that IPM must evolve to its next step and become more biologically intensive in its approach for the future to prevent pesticide pollution. However, the adoption of IPM programs will not exclude the use of pesticides, and they remain as integral and indispensable tools in IPM. According to Ware (1983), pesticides remain the first line of defense in pest control when crop injuries and losses reach the economic threshold and when pest out breaks occur.

2.8 PESTICIDE REGISTRATION

Registration of pesticides can be defined as: permission for using, selling, importing and exporting of a pesticide in a specific area or country after fulfilling the requirements of registration. These requirements normally include defining the chemical composition of the product, physical and chemical characteristics, its behavior in the environment, its toxicity to mammals and the target pest(s) as well as the precautions required during application (Abdel-Al Hammed and Abdel-Majeed, 1988).

2.8.1 PESTICIDE REGISTRATION IN THE UNITED ARAB EMIRATES

Pesticide management in UAE is governed by:

a. Federal law No. (4) of the year 1982 on agricultural pesticides.
b. Ministerial decision No. (97) of the year 1993 on the executive statute of the Federal Law No. (41) of the year 1992 regarding agricultural pesticides.
c. In response to Article No. (3) of the Ministerial Decision No. (97), registration of pesticides to be imported and used in the country commenced in December, 1995, based on the following documents:

    1. Registration certificate for the formulation from any country with a well-developed pesticide registration system.

2. Certificate of origin of the Technical Grade Active Ingredient (TGAI).
3. Certificate of analysis of the TGAI.
4. Complete technical data including: the physical and chemical properties, LD_{50} values (oral and dermal) of the TGAI; physical properties, different uses, methods of analysis of the formulation; methods of residue analysis; fate in the environment and the different pathways; safety data, disposal of wastes and empty packing materials, etc.
5. Complete toxicological studies particularly on carcinogenicity, mutagenicity, teratogenicity and neurogenicity.
6. A report on the field trials that are performed locally on the formulation.
7. A label in Arabic or both Arabic and English languages, prepared according to the model specimen of the Ministry.

A technical committee of three persons examines these documents; when found satisfactory, a registration certificate valid for five years is issued from the Ministry of Agriculture and Fisheries. After that, the pesticide can be imported, sold and used in the UAE. Upon application by the local agent, an import permit validity for one year is issued (Abdullah, 1999).

2.8.2 PESTICIDE REGISTRATION IN AUSTRALIA

In Australia the body that is responsible for registration of agricultural and veterinary chemicals is the National Registration Authority (NRA). No agricultural or veterinary chemical can be sold, supplied, distributed or used in Australia unless the NRA has already registered it.

Registration is required for products such as herbicides, fungicides, and insecticides used for plant protection, in the home, garden, and for veterinary medicines and treatments. The output of the registration process is to provide the public with assurance that products on the market are safe and effective when used as explained and do not have any adverse impact on the environment. Registration also ensures that unacceptable residues from agricultural chemicals and their metabolites do not appear in agricultural commodities destined for human and animal consumption.

Registration Requirements

To register a new product or to change the formulation of an already registered chemical, a comprehensive data package must be submitted to the NRA. However, this differs when registration is oriented towards a product that is similar to an already registered one.

Technical information on the product's chemistry and manufacture, toxicology, metabolism and toxic kinetics, residues, efficacy, occupational health, and fate of the chemical on the environment must be supplied. All this information should be within acceptable scientific principles, which include laboratory studies and trials (NRA, 1998).

As far as residues are concerned, a proposed MRL and the relevant data on the MRLs in Australia, other countries, and the Codex should be submitted. Data should also include the detail of the proposed use pattern, dose rate, application regime, and proposed safety period. The nature, level and safety of residues and metabolites resulting from the proposed use pattern of the product must also be included. This should contain residues in crops, livestock, poultry, eggs, milk and (if possible) wool. The fate of residues during storage, processing, and cooking is also important. (NRA, 1998).

In addition, the NRA obtains specialist advice from three Commonwealth Government agencies: the Department of Health and Family Services which evaluates toxicology data submitted by applicants to determine any health risk may be posed to the community. The Environment Protection Group, which evaluates the environmental impact of the product and recommends, measures to avoid or reduce its adverse environmental effects. The National Occupational Health and Safety Commission ensures that the risks that arise as a result of worker exposure to the chemical is at a minimum. The State Department of Agriculture and sometimes State Environmental Authorities will give advice on efficiency and target species safety (NRA, 1998).

Registration Process

Registration may take up to 18 months in the case of a new product with a new active ingredient. There are two stages in this process; screening and evaluation. Screening is to ensure that all the documents are available and correctly prepared. Evaluation begins when a complete application is submitted.

The time taken to evaluate an application is clocked by a computerized tracking system, which is activated when an application is accepted for evaluation.

To maintain product registration, registrants must renew it annually by 30 June for the following financial year. The NRA notifies registrants of the need to renew registration before their current registration expires (NRA, 1998).

National Permit Scheme

A situation may occur where it is necessary to use an unregistered product or a registered product in an unapproved manner. Three defined situations are included here: emergencies; such as outbreaks of contagious disease or exotic pests for which no registered product exists. Minor use; the use of a product on a crop or animal on a small scale, and research which can involve the use of unregistered products to generate data needed for registration.

Permits issued for minor or emergency uses of registered products are known as off-label permits, where as those issued for research trials are named trial permits. Without such permits, these actions are considered an offence (NRA, 1998).

2.8.3 PESTICIDE REGULATION IN THE USA

In the United States, pesticides are regulated by a myriad of laws and agency rules. No less than fourteen different Federal Acts control some aspects of the manufacture, registration, distribution, use, consumption, and disposal of pesticides. The bulk of pesticide regulation falls under the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA)(Extoxnet, 1993). This legislation governs the registration, distribution, sale and use of pesticides. The Environmental Protection Agency is responsible for the administration of this act and for establishing rules and regulations consistent with the Acts intent.

The three broad categories of concern with pesticide regulation focus on (a) the registration of new pesticide and their re-registration; and the re-registration of exiting pesticides and on (b) establishing and monitoring of pesticide levels in food products and on (c) the monitoring of pesticide levels in the environment and especially in ground and surface water (Extoxnet, 1993).

Pesticide Registration

A. New Pesticides

The EPA is responsible under FIFRA for registering new pesticides to ensure that, when used according to label directions, they will not pose unreasonable risks to human health or the environment. FIFRA requires the EPA to balance the risk of pesticide exposure to human health and the environment against the benefits of pesticide use to society and the economy. Registration of a pesticide will be granted if, after a careful consideration of health, economic, social and environmental cost and benefits, the benefit of the pesticide's use outweighs the costs of its use.

Pesticide registration decisions are based primarily on the EPA´s evaluation of data provided by applicants. Depending on the type of pesticide, the EPA can require up to 70 different kinds of specific tests. For a major food crop, pesticide testing can cost the manufacturer many millions of dollars.

Testing is needed to determine whether a pesticide has the potential to cause adverse effects on humans, wildlife, fish, and plants. Potential human risks, which are identified by using the results of laboratory tests, include acute toxic reactions, such as poisoning and skin and eye irritation, as well as possible long-term effects like cancer, birth defects, and reproductive system disorders. Data on "environmental fate" are also required so that the EPA can determine, among other things, whether a pesticide poses a risk to the environment.

The EPA may classify a product for restricted use if it warrants special handling due to its toxicity. Restricted Use Pesticides (RUP) may be used only by or under the supervision of certified applicators trained to handle toxic chemicals. This classification must appear on product labels.

During registration review, the Agency may also require changes in proposed labeling, use location, and application method. If the pesticide is destined for use on a food or feed crop, the applicant must petition the EPA for establishment of a food tolerance level.

A brand-new active ingredient may need six to nine years to move from development in the laboratory, through to full completion of EPA registration requirements, and finally to the retail shelves. This time frame includes at least two or three years to obtain registration approval from the EPA

B. Registration of Existing Pesticides:

Re-registering existing pesticides that were originally registered before the current scientific and regulatory standards were formerly established is also the task of the EPA. The re-registration process ensures that:

a. Recent data sets are developed for the chemical.
b. Modifications are made to registration, labels, and tolerances as necessary to protect human health and the environment.
c. Special review or other regulatory actions are initiated to deal with any unreasonable risks.

All the above information about pesticide registration in USA is obtained from Extension Toxicology Network (Extoxnet, 1993).

2.9 THE PESTICIDES SELECTED FOR THE STUDY

Certain pesticides were selected for the purpose of this study according to the importance of their use in UAE for controlling the major pests, which attack tomato and cucumber. These are diazinon, dimethoate, chlorpyrifos, chlorothalonil, and metalaxyl. In the following section contains more detailed information about these chemicals.

2.9.1 DIAZINON

Formulation

It is available as dust, emulsifiable concentrate and oil solutions, granules, seed dressing, ULV. wettable powder, polymeric microcapsules. It is also used in mixtures with some others insecticide like captan, chlorpyrifos, lindane and cypermethrin.

Regulatory status

According to the EPA diazinon is classified as a Restricted Use Pesticide (RUP) and is for professional use only. In 1988, the EPA cancelled registration of diazinon for use on golf courses and sod farms because of die-offs of birds that often congregated in these areas. It is classified as class-II moderately toxic or toxicity class III – slightly toxic, depending on the formulation and consequently bears the signal word warning CAUTION.

Toxicity

A- Acute Toxicity

Toxic effects of diazinon are due to the inhibition of acetylcholinesterase, the range of doses that results in toxic effects varies widely with formulation and with the individual species being exposed. Technical oral LD_{50} for rat is 1250 mg/Kg .The inhalation LC_{50} (4 hours) in rat is 5.4 mg/L. In rabbit dermal LD_{50} is > 2020 mg/Kg (Farm Chemical, 2000). Some formulations of the compound can be degraded to more toxic forms. This transformation may occur in air, particularly in the presence of moisture and by ultra violet radiation. Most modern diazinon formulations in the U.S. are stable and do not degrade easily (U.S. Public Health Service, 1995). The symptoms associated with diazinon poisoning in humans includes weakness, headache, tightness in the chest, blurred vision, nausea, vomiting, diarrhea, abdominal cramps, and slurred speech. Death has occurred in some instances from both dermal and oral exposures at very high levels (Gallo and Lawryk, 1991).

B- Chronic Toxicity

This effect has been observed at doses ranging from 10 mg/Kg/day for swine to 1000 mg/Kg/day for rats. Inhibition of red blood cell cholinesterase, and enzyme response occurred at lower doses in the rats (Gallo and Lawryk, 1991).

C-Teratogenic effects

The data on teratogenic effects due to chronic exposure are inconclusive. Eisler (1986) demonstrated that injection of diazinon into chicken eggs resulted in skeletal and spinal deformities in the chicks. Bobwhite quail born from eggs treated in a similar manner showed skeletal deformities but no spinal abnormalities. Acetylcholine was significantly affected in this latter study.

In another study, Vettorazzi (1976) demonstrated that tests with hamsters and rabbits at low doses (0.125, 0.25 mg/Kg/day) showed no developmental effect, while tests with dogs and pigs at higher levels (1.0, 10.0 mg/Kg/day) revealed gross abnormalities.

D- Carcinogenic effects

According to the study of Gallo and Lawryk (1991) tests on rats over a 2-year period at moderate doses (45 mg/Kg) did not cause tumor development.

E- Organ toxicity

As diazinon itself is not a potent cholinesterase inhibitor, Gallo and Lawryk (1991) showed that in animals it is converted to a diazoxon compound that is a strong enzyme inhibitor.

F- Fate in humans and animals

The half-life of diazinon in animals is about 12 hours. The product is passed out of the body through urine and in feces. The metabolites account for about 70% of the total amount excreted (Extension Toxicology Network, 1996). Cattle exposed to diazinon may store the compound in their fat over the short term (U.S. Public Health Service, 1995). The same authors stated that application of diazinon to the skin of cows resulted in trace amounts in milk 24 hrs after the application.

Environmental fate

A. Soil and water

According to Wauchope *et al* (1992) the half-life of diazinon is 2 to 4 weeks. Bacterial enzymes can speed the breakdown of diazinon and have been used in treating situations such as spills (Howard, 1991). The same author showed that the compound was detected in 54 wells in California and in tap water in Ottawa, Canada, and in Japan. Diazinon rarely migrates below the top half inch in soil, but in some instances it may contaminate ground water (Extension Toxicology Network, 1996). On the other hand the breakdown of this pesticide in water is dependent on pH. At very low pH levels, one half of the compound disappeared with 12 hrs while in neutral levels, the compound needed 6 month to degrade to one half of the original concentration (Howard, 1991).

B. Vegetation

According to Bartch (1974) the persistence of diazinon tends to increase in plants when two factors are fulfilled: low temperatures and high oil content. In leafy vegetables the half-life is rapid followed by forage crops and grass with a range between 2 – 14 days.

The same author said that residues of the pesticide are present after 9 days in only 10% of treated rice plants.

The ADI is estimated to be 0.002 mg./Kg/day (codex, 2000), while the Reference Dose (RFD) is 9 x 10-5 mg/Kg/day (U.S. EPA. 1994).

2.9.2 DIMETHOATE

Formulation

Dimethoate is available as emulsifiable concentrate, dust, aerosol, and ULV

Toxicity:

A- Acute toxicity

Dimethoate is considered as moderately toxic compound and placed in class-II. The reported acute and LD_{50} values for the technical product (rat) is 235 mg/Kg. Dermal > 400 mg/Kg. However an oral LD_{50} as low as 28.30 mg/Kg. has been reported (Kidd and James, 1991). The same authors reported that, the product is not known to be an eye or skin irritants of laboratory animals. Although severe eye irritation has occurred in workers manufacturing Dimethoate which may be attributed to impurities (Gallo and Lawryk, 1991). Kidd and James found that, 4 hours LC50, by inhalation, is greater than 2 mg/L, which indicate slight toxicity. Dimethoate can cause cholinesterase inhibition in humans. That is, it can over stimulate the nervous system causing nausea, dizziness, confusion and at very high exposures respiratory paralysis and death.

B- Chronic toxicity

In a study with humans given oral and doses of 5, 15, 30, 45 or 60-mg/day for 57 days, cholinesterase inhibition was observed only in the 30 mg/day and higher dosage groups (Gallo and Lawryk, 1991). Repeated or prolonged exposure to organophosphates may result in the same effects as acute exposure, including the delayed symptoms effect reported in workers with repeated exposure, these include impaired memory and reduced concentration, disorientation, severe depression, confusion, speech difficulty. Influenza like condition with headache, nausea, loss of appetite, and malaise has also been reported (Gallo and Lawryk, 1991).

C- Reproductive effects

Gallo and Lawryk (1991) noticed decreased in reproductive, pup survival, and growth rates of surviving pups when mice given 9.5 to 10.5 mg/Kg/ day dimethoate in their drinking water. Adults in this study exhibited reduced weight gain without their survival being affected. In another study conducted by the same scientists for three generations in mice, 2.5 mg/Kg/day did not decrease reproductive performance or pup survival.

D- Teratogenic effects

Dimethoate showed to be teratogenic in cats and rats (U.S. Public Health Service, 1995). They found that a dosage of 12 mg/Kg/day given to pregnant cats increased the incidence of extra toes in kittens. The same dosage given to pregnant rats produced birth defects related to bone formation, runting and malfunction of the bladder. Dosages of 3-6 mg/Kg/day were not teratogenic in cats or rats (Gallo and Lawryk, 1991).

E- Carcinogenic effects

Gallo and Lawryk (1991) observed an increase in malignant tumors, which is not dose dependent, in rats given oral doses of 5, 15, or 30 mg/kg/day dimethoate for over a year. Thus the evidence of carcinogenicity, even with high dose, long-term exposure, is inconclusive.

F- Fate in humans and animals

The rate of metabolism and elimination of the product varied in several species tested. Amongst several mammalian species tested, dimethoate appears to be less toxic to those animals with higher liver–to–body weight ratios and to those with the highest rate of dimethoate metabolism (Gallo and Lawryk, 1991). They found that dimethoate is rapidly metabolized by mammals, where rats excreted about 50 – 60 % of administered doses in urine, expired air and feces within 24 hours.

Environmental fate

A- Breakdown in soil and water:

Because it is rapidly broken down by soil microorganisms, dimethoate will be broken down faster in moist soils. Dimethoate is slightly soluble in water, and it adsorbs very weakly on soil particles so may be subject to considerable leaching (Wauchope *et al.* 1992). The same authors reported that dimethoate half-lives ranged between 4 – 16 days, although, in some cases it reached 122 days, but a representative value may be about 20 days. It is degraded by hydrolysis, especially in alkaline soils and evaporates from dry soil and surfaces losses due to evaporation of 23 – 40 % of applied dimethoate have been reported (Howard, 1991). The same author stated that 77% loss due to biodegradation take place in a non-sterile clay loam soil after 2 weeks.

The half-life of dimethoate in raw river water was 8 days, as disappearance possibly due to microbial action or chemical degradation (Howard, 1991).

The same scientist stated that dimethoate in water is not expected to adsorb to sediments or suspended particles, nor to bioaccumulate in aquatic organisms. It is subjected to significant hydrolysis, especially in alkaline waters.

ADI: 0.002 mg/Kg/day (Codex, 2000)

RFD: 0.0002 mg/Kg/day (U.S. EPA, 1994)

2.9.3 CHLORPYRIFOS

Formulation

It is available as granules, wettable powders, dustable powders, and emulsifiable concentrates.

Toxicity

It classified as class II, moderately hazardous (WHO, 1999) Its products bear the signal WARNING or CAUTION, depending on the toxicity of the formulation. The EPA has established a 24 – hour's reentry interval for crop areas treated with EC or WP formulations unless workers wear protective clothing (Extension Toxicology Network, 1996).

A- Acute toxicity

Poisoning from chlorpyrifos may affect the central nervous, cardio-vascular, and respiratory systems. It is also a skin and eye irritant (Gallo and Lawryk, 1991). They stated that skin absorption of chlorpyrifos is limited. Plasma cholinesterase activity has been shown to be inhibited when chlorpyrifos particles are inhaled (U.S. Public Health Service, 1995). The oral LD_{50} of the product in rats is 95 to 270 mg/Kg (Kidd and James, 1991). The dermal LD_{50} is greater than 2000 mg/Kg in rabbits (Dow Chemical, 1986). The 4-hour inhalation LC_{50} for chlorpyrifos in rats is greater than 0.2 mg/L (Dow Elanco, 1992).

B- Chronic toxicity

When technical chlorpyrifos was fed to dogs for 2 years, increased liver weight occurred at 3.0 mg/Kg/day. Signs of cholinesterase inhibition occurred at 1 mg/Kg/day. Rats and mice given technical chlorpyrifos in the diet for 104 weeks showed no adverse effects other than cholinesterase inhibition (U.S. EPA, 1989). Two year feeding studies using doses of 1 and 3 mg/Kg/day of chlorpyrifos in rats showed moderate depression of cholinesterase (Gallo and Lawryk, 1991). However, cholinesterase levels recovered when the experimental feeding discontinued. Human volunteers who ingested 0.1 mg/Kg/day of chlorpyrifos for 4 weeks showed significant cholinesterase inhibition (American Conference of GIH, 1986).

C- Reproductive effects

Current evidence indicates that chlorpyrifos does not adversely affect reproduction. No effects were observed in animals tested at dose levels up to 1.2 mg/Kg/day (U.S. Public Health Department, 1995). No effects on reproduction occurred in a three-generation study with rats fed dietary doses as high as 1 mg/Kg/day (U.S. EPA, 1989). Death of newborn offspring was observed when rats were fed 1.0 mg/Kg/day for two generations (Gallo and Lawryk, 1991).

D- Teratogenic effects

No teratogenic effects in offspring were found when pregnant rats were fed doses as high as 15 mg/Kg/day for 10 days. When pregnant mice were given doses of 25 mg/Kg/day for 10 days, minor skeletal variations and a decrease in fetal length occurred (Dow Chemical, 1986).

E- Carcinogenic effects

There was no increase in the incidence of tumors when rats were fed 10 mg/Kg/day for 105 wks (U.S. EPA, 1989). Accordingly, there is no evidence that the chemical is carcinogenic.

F- Fate in humans and animals

Chlorpyrifos is readily absorbed into the bloodstream through the gastrointestinal tracts if it is ingested, inhaled, or absorbed through the skin (U.S. Public Health Service, 1995). After a single oral dose, the half-life of chlorpyrifos in the blood appears to be about one day (National Institute for Occupational Safety and Health, 1986). However, chlorpyrifos is eliminated primarily through the kidneys (U.S. Public Health Service, 1995). Following and intake of chlorpyrifos by rats 90 % is removed in the urine and 10% is excreted in the feces (Kidd and James, 1991). It is detoxified quickly in rats, dogs, and other animals (U.S. Public Health Service, 1995). The major metabolites found in rat urine after a single oral dose is Trichlorpyridinol (TCP).

According to the same authors TCP does not inhibit cholinesterase and it is not mutagenic. They continued to say that, chlorpyrifos does not have a significant bioaccumulation potential. Gallo and Lawryk, (1991) showed that a portion of the chemical is stored in fat tissues but it is eliminated in humans, with a half-life of about 62 hrs. In another study when chlorpyrifos (Dursban) was fed to cows, unchanged pesticide was found in the feces, but not in the urine or milk. (U.S. EPA, 1984). However, it was detected in the milk of cows for 4 days following spray dipping with a 0.15 % emulsion. The maximum concentration in the milk was 0.304 ppm (Gallo and Lawryk, 1991).

Environmental fate

A- Breakdown in Soil, Groundwater, and water

The half-life of chlorpyrifos in soil is usually between 60 and 120 days, but can range from two weeks to over 1 year, depending on the soil type, climate, and other conditions (Howard, 1991). It is considered as moderately persistent in soils. However, It is less persistent in higher pH soils (Racke, 1992). Soil half-life was not affected by soil texture or organic matter content. In a parallel study with anaerobic soils the half-life was found to be 15 days in loam and 58 days in clay soil (U.S. EPA, 1989). Chlorpyrifos adsorbs strongly to soil particles and is not readily soluble in water (Wauchoge *et al.* 1992). It is therefore immobile in soils and unlikely to leach or contaminate groundwater. However, TCP adsorbs weakly to soil particles and appears to be moderately mobile and persistent in soils (U.S. EPA, 1989). In water volatilization is probably the primary route of loss of chlorpyrifos, and volatility half-lives of 3.5 and 20 days have been estimated for pond water (Racke, 1992). In water at Ph 7.0 and 25°C, it had a half-life of 35 78 days (Howard, 1991). The rate of hydrolysis is constant in acidic to neutral waters, but increases in alkaline waters.

B- Vegetation

In vegetation, some research suggests that this insecticide and its soil metabolites can accumulate in certain crops (U.S. Public Health Service, 1995). Its residues remain on plants for approximately 10-14 days.

ADI: 0.01 mg/Kg/day (Lu, 1995)

RFD: 0.003 mg/Kg/day (U.S. EPA, 1994).

2.9.4 CHLOROTHALONIL

Formulation

It is available as flowable formulation, water dispersible granules, wettable powders, and exothermic dusts.

Toxicity

A- Acute toxicity

Chlorothalonil is slightly toxic to mammals, but it can cause severe eye and skin irritation in certain formulations (Smith, 1991). Very high doses may cause a loss of muscle coordination, rapid breathing, nose bleeding, hyperactivity, and death. In some cases dermatitis, vaginal bleeding, and kidney tumors may also occur (U.S. National Library of Medicine, 1995). The oral LD_{50} is greater than 10,000 mg/Kg in rats and 6000 mg/Kg in mice (Kidd, 1991). According to the same authors the acute dermal LD_{50} in both albino rabbits and rats was 10,000 mg/Kg.

B- Chronic toxicity

According to U.S. Environment Protection Agency (1987) there were no effects on physical appearance, behavior, or survival on rats fed a range of doses of chlorothalonil in different tests of varying length of time. In the same study they showed that human eye and skin irritation were linked to chlorothalonil exposure. On the other hand, the study suggests that chlorothalonil will not affect human reproduction at expected exposure levels.

C- Teratogenic effects

In another long term studies with rats fed high doses of chlorothalonil; only reduced weight for males and females was observed (U.S. EPA, 1987). No birth defects were observed in these or other studies (U.S. EPA, 1985).

D- Mutagenic effects

Different mutagenic studies with animals, bacteria, and plants indicated that chlorothalonil does not cause any mutagenic changes (U.S. National Library of Medicine, 1995).

E- Organ toxicity

Vettorazzi (1979) showed that Kidney toxicity occurred in rats and dogs fed high dietary levels of chlorothalonil, in addition kidney enlargement, reduced urine output, and colour change were also observed.

F- Carcinogenic effects

Male and female rats fed Chlorothalonil daily over a lifetime developed carcinogenic and benign kidney tumors at the higher doses (U.S EPA, 1987).

According to the same reference, females developed tumors in the fore - stomach area and males showed carcinogenic and benign kidney tumors when mice were fed high daily doses of chlorothalonil for 2 years.

G- Fate in humans and animals

Studies revealed in U.S National Library Medicine NLM (1995) indicate that rats and dogs fed very high doses for 2 years eliminated almost all of the chemical in urine, feces, and expired air - residues of the chemical have not been found in the tissues or milk of dairy cows.

Environmental fate

A- Soil and groundwater

Chlorothalonil has high binding and low mobility in silty loam and silty clay loam soils, and has low binding and moderate mobility in sand (U.S. EPA, 1987). It is considered as moderately persistent. It's half life is from 1 3 months in aerobic soils. Increased soil moisture or temperature increases chlorothalonil degradation (U.S. NLM, 1995).

In a survey of 560 groundwater samples no chlorothalonil residues were found (U.S. EPA, 1987).

B- Vegetation

Chlorothalonil is a fairly persistent fungicide on plants, depending on the rates of application. Small amounts of one metabolite may be found in harvested crops but it will dissipate over time (Vettorazzi, 1979).

ADI: 0.03 mg/Kg/day (Lu, 1995)

RFD: 0.015 mg/Kg/day (U.S. EPA, 1995)

2.9.5 METALAXYL

Formulation

It's available as emulsifiable concentrate, granules, flowable, and wettable powder.

Regulatory status

Metalaxyl is a slightly toxic compound with class III toxicity in the WHO classification (WHO, 1999). Labels for products containing metalaxyl must bear the Signal word CAUTION.

Toxicity

A- Acute toxicity

The oral LD_{50} (Technical) in rats is 669 mg/kg and the dermal LD_{50} is greater than 3100 mg/kg (U.S. National Library of Medicine, 1995). No information was available regarding the inhalation toxicity of metalaxyl.

B- Chronic toxicity:

A 90-day study of rats exposed to 0.1 to 2.5 mg/kg/day in their diet showed some cellular enlargement in the liver at the highest dose (Ciba Giegy, 1992). Increased blood alkaline phosphate and liver-to-brain weight were manifested at the highest dose in dogs in a 6-month study when the animals were fed a diet of approximately 0.04-0.8 mg/kg/day (Ciba Giegy, 1992).

C- Reproductive effects

The data from a three-generation rat study, suggest that metalaxyl is unlikely to cause reproductive effects (Ciba Giegy, 1992). In this study the animals were fed up to 2.5 mg/kg/day and no compound related maternal toxicity or reproductive effects were observed.

D-Teratogenic effects

Rats and rabbits given a dosage of 120 mg/kg/day on day 6-15 and 20 mg/kg/day on day 6-18 by stomach tube, respectively, exhibited no embryo toxicity or teratogenicity were observed (Ciba Giegy, 1992).

E- Mutagenic & carcinogenic effects

The available studies including a dominant lethal assay in male mice indicate that metalaxyl has no mutagenic potential. The studies of carcinogenicity are inconclusive (Ciba Giegy, 1992).

F- Fate in humans and animals

Rapid metabolism and excretion via urines feces were observed in rats and goats (Ciba Giegy, 1992). In another study, the same authors found in Forty-day feeding with dairy cattle at 15 ppm/day, showed less than 0.01 ppm was stored in the muscle and fat.

3.0 CONSUMER FOOD SAFETY SURVEY

3.1 INTRODUCTION

A questionnaire was prepared to investigate the opinions, concerns and attitudes of the UAE population about a range of issues which are listed below:

1. Their concerns about pesticide residues in food commodities, fresh fruits and vegetables.
2. The geographical origin of the food they buy.
3. The levels of consumption for tomato and cucumber.
4. The measures that consumers used to reduce pesticide residues on fresh fruits and vegetables.
5. To determine if there is general support for the supply pesticide free produce.
6. The public confidence in the ability of the authorities to ensure food safety for the consumer.
7. To understand the sources of information available to consumers, about pesticide residue issues.
8. To understand the kind of consumers knowledge about possible effects of pesticide residues on human health.

There is a need to conduct such a survey to give some idea about consumer attitudes on pesticide residues in food that might assist planners who are responsible for food safety issues.

The scope of this survey was to measure the consumer levels of awareness on pesticide issues, to understand their attitudes, and to explore what steps are needed to ensure their safety.

The survey was conducted in several locations and was not limited to people in the market places only, but included office staff and others in the workplace who were also surveyed.

Tomato and cucumber were the crops targeted in this survey because of their importance in the daily diet in the UAE. Also these two crops are among the few which are grown successfully in the UAE.

The survey was prepared in English, and an Arabic translation was used when needed. It was conducted from September 2000 to February 2001, by the author. The people were selected randomly, and the need to survey different groups of shoppers was taken into consideration (males, females, different nationalities, different groups of ages, different educational levels). The survey was conducted in different cites in the UAE (Abu Dhabi, Al-Ain, Dubai, Sharjah, Ajman, Fujairah, Ras al-Khaimah & Umm al-Qaiwain).

Personal survey took approximately 15 to 30 minutes to complete in the cases where face to face surveys, were performed. In some instances, the questionnaire was sent home with the subject and collected from them in the following day.

3.2 THE QUESTIONNAIRE

Consumer Food Safety Survey
Fresh Produce in the Marketplace

Dear Consumer,

This questionnaire is intended to serve scientific purposes only. The information you provide will be used anonymously.

Please answer all the questions honestly with the actual procedures that you normally use.

Your cooperation is highly appreciated.

Thank you.

<u>Personal Details</u>

1. Age: ______________________.
2. Sex: ______________________.
3. Nationality: ________________.
4. Educational status: __________.
5. City (In UAE): _____________
6. Who does most of the shopping for your family (household)?
   I. You ☐
   II. Another person ☐

7. Where do you normally shop?

   A. Supermarket ☐

   B. Outdoors Market ☐

   C. Other ☐

Date: __________

Q1. Are you concerned, generally, about pesticide residues on food?

A. Yes. ☐ B. No. ☐

If your answer is **yes**, what do you know about this issue?

____

____

____

____

Q2. Which of these listed below are you concerned about with respect to the issue of pesticide contamination? Indicate the order of importance. (e.g. 1,2,3)

I. Fresh fruits & vegetables. ☐

B. Juices. ☐

C. Baby food. ☐

D. Other ☐

(State which)______________________________________

Q3. When you buy fresh fruits and vegetables such as tomato and cucumber, do you inquire about its origin?

A. Yes. ☐ B. No. ☐

If the answer of above question is yes, Please give the reasons for your inquiry?

____

____

____

Q4. Which of the following vegetables do you consume most of?

I. Cucumber. ☐
B. Tomato. ☐

Q5. What quantity of cucumber do you consume per week? (Per person)

I. Quarter kilogram. ☐
II. Half kilogram. ☐
III. One kilogram. ☐
IV. Other. State the quantity, ______ kg

Q6. What quantity of tomato do you consume per week? (Per person)

I. Quarter kilogram. ☐
II. Half kilogram. ☐
III. One kilogram. ☐
IV. Other. State the quantity, ______ kg

Q7. Do carry out any measures in order to reduce pesticide residues on fresh fruits and vegetables?

I. Yes. ☐

II. No. ☐

Q8. If your answer to Question 7 was Yes, Which practice do you use?

I. Washing. ☐

II. Peeling. ☐

III. Both A & B. ☐

IV. Other. ☐

(Please state)____

Q9. Would you support a policy of giving agricultural commodities, which are free from pesticide residues higher prices than produce which are not?

I. Yes. ☐

II. No. ☐

Q10. Do you have any specific concerns about locally produced cucumbers and tomatoes?

I. No. ☐

II. Yes. ☐

(Comments)____

____

____

____

Q11. If your answer for question 10 was Yes, from where you have received your information?

I. Talking with other people. ☐
II. Newspapers. ☐
III. Television or Radio programs. ☐
IV. Scientific evidence(s). ☐
V. Personal evidence(s). ☐

Q12. What knowledge do you have about the possible effects of pesticides residues on human health?

I. None ☐
II. Some ☐

(Please state)____

Q13. Do you have any comments or remarks to make about this questionnaire?

____

____

____

3.3 RESULTS

The sample was selected taking into consideration the multinational society of the UAE. Accordingly, the sample was divided into different groups, males and females, UAE nationals and other nationalities, by educational level and by age. The collected data was tabulated and analyzed as shown below.

Table 14: Population demographics of the sample.

#	Key Variable	Males	Females	Total
1	***Number of participants***	84(28%)	216(72%)	300(100%)
2	***Age***			
	Less than 30 years	27(32%)	191(88%)	218(73%)
	More than 30 years	57(68%)	25(12%)	82(27%)
	Total	84(100%)	216(100%)	300(100%)
3	***Educational status***			
	University Education	65(77%)	80(37%)	145(48%)
	Secondary Education	10(12%)	90(42%)	100(33%)
	Primary Education or less	9(11%)	46(21%)	55(19%)
	Total	84(100%)	216(100%)	300(100%)
4	***Nationality***			
	UAE	20(10%)	180(90%)	(67%) 200
	Other	64(64%)	36(36%)	(33%)100
	Total	84(100%)	216(100%)	300(100%)
5	***Shopping person***			
	Person interviewed	50(60%)	186(86%)	236(79%)
	Another person	34(40%)	30(14%)	64(21%)
	Total	84(100%)	216(100%)	300(100%)
6	***Where do you shop***			
	Supermarket	55(65%)	176(81%)	231(77%)
	Outdoors market	29(35%)	40(19%)	69(23%)
	Other	0.0(0.0%)	0.0(0.0%)	0.0(0.0%)
	Total	84(100%)	216(100%)	300(100%)

Table 15a: **The proportion of respondents indicating general concern about pesticide residues in food commodities. (By nationality and gender)**

	Males	Females	Total
UAE Nationals	17(85%)	90(50%)	107(54%)
Other Nationality	51(80%)	29(81%)	80(80%)
Total	68(81%)	119(55%)	187(62%)

Table 15b: **Those giving reasons for their concern.**

	Males	Females	Total
UAE Nationals	14(82%)	45(50%)	59(55%)
Other Nationality	45(88%)	23(79%)	68(85%)
Total	59(87%)	68(57%)	127(68%)

Table 15c: **The proportion of respondents indicating general concern about pesticide residues in food commodities. (By age)**

Ages	Males	Females	Total
Less than 30 years	13(65%)	98(45%)	111(51%)
More than 30 years	53(93%)	23(92%)	76(93%)
Total	66(80%)	68(31%)	187(62%)

Table 15d: **The proportion of respondents indicating general concern about pesticide residues in food commodities. (By educational status)**

Educational status	Male	Female	Total
University Education	63(97%)	77(96%)	140(97%)
Secondary Education	4.0(40%)	38(42%)	42(42%)
Primary Education or less	1.0(11%)	4.0(9.0%)	5.0(9.0%)
Total	68(81%)	119(55%)	187(62%)

Table 16: The level of importance (by rank) placed on concern about pesticide residues among the selected commodities.

Type of commodity	Highest level	Intermediate	Lowest level	Total
Fresh Fruit & vegetables	207(69.0%)	63(21%)	30(10%)	300(100%)
Fruit Juices	0.0(0.0%)	84(28%)	216(72%)	300(100%)
Baby food	93(31.0%)	153(51%)	54(18%)	300(100%)
Other	0.0(0.0%)	0.0(0.0%)	0.0(0.0%)	0.0(0.0%)
Total	300(100%)	300(100%)	300(100%)	

Table 17a: Those showing concern about the origin of the selected vegetables (Tomatoes and Cucumber).

	Males	Females	Total
UAE Nationals	14(70%)	104(58%)	118(59%)
Other Nationality	51(79%)	16(44%)	67(67%)
Total	65(77%)	120(56%)	185(62%)

Table 17b: Those giving reasons for their concern about the origin of the selected vegetables (Tomatoes and Cucumber).

	Males	Females	Total
UAE Nationals	11(79%)	36(35%)	47(40%)
Other Nationality	35(67%)	9.0(56%)	44(66%)
Total	46(71%)	45(38%)	91(49%)

Table 17c: Those showing concern about the origin of the selected vegetables (Tomatoes and Cucumber). (By age)

	Males	Females	Total
Less than 30 years	14(52%)	96(50%)	110(50%)
More than 30 years	54(95%)	21(84%)	75(91%)
Total	68(81%)	117(54%)	185(62%)

Table 17d: **Those showing concern about the origin of the selected vegetables (tomatoes and cucumber). (By educational status)**

Educational Status	Males	Females	Total
University Education	61(94%)	74(93%)	135(93%)
Secondary Education	5.0(50%)	35(39%)	40(40%)
Primary Education or less	2.0(22%)	8.0(17%)	10(18%)
Total	68(81%)	117(54%)	185(62%)

Table 18a: **Relative ranking of consumption of tomatoes and cucumbers among males and females.**

Crop	Males	Females	Total
Mostly Tomatoes	75(89%)	175(73%)	250(83%)
Mostly Cucumber	9.0(11%)	41(19%)	50(17%)
Total	84(100%)	216(100%)	300(100%)

Table 18b: **Relative ranking of consumption of tomatoes and cucumbers among UAE nationals and other nationalities.**

Crops	UAE Nationals	Other Nationalities	Total
Mostly Tomatoes	156(78%)	94(94%)	250(83%)
Mostly Cucumber	44(22%)	6.0(6.0 %)	50(17%)
Total	200(100%)	100(100%)	300(100%)

Table 19a: **Rate of consumption of cucumber (per person per week). (By gender)**

Consumption rate (kg): Cucumber	Males	Females	Total
1/4 kg	23(27%)	62(29%)	85(28%)
1/2 kg	21(25%)	66(31%)	87(29%)
1.0 kg	40(48%)	88(41%)	128(43%)
Other quantity	0.0(0.0%)	0.0(0.0%)	0.0(0.0%)
Total	84(100%)	216(100%)	300(100%)

Table 19b: Rate of consumption of cucumber (per person per week). (By nationality)

Consumption rate (kg): Cucumber	UAE Nationals	Other Nationalities	Total
1/4 kg	58 (29%)	27(27%)	85(28%)
1/2 kg	60(30%)	27(27%)	87(29%)
1.0 kg	82(41%)	46(46%)	128(43%)
Other quantity	0.0(0.0%)	0.0(0.0%)	0.0(0.0%)
Total	200(100%)	100(100%)	300(100%)

Table 20a: Rate of consumption of tomatoes (per person per week). (By Gender)

Consumption rate (kg): Tomatoes	Males	Females	Total
1/4 kg	5.0(6.0%)	20(9%)	25(8.0%)
1/2 kg	18(21%)	66(31%)	84(28%)
1.0 kg	61(73%)	130(60%)	191(64%)
Other quantity	0.0(0.0%)	0.0(0.0%)	0.0(0.0%)
Total	84(100%)	216(100%)	300(100%)

Table 20b: Rate of consumption of tomatoes (per person per week). (By nationality)

Consumption rate (kg): Tomatoes	UAE Nationalities	Other Nationalities	Total
1/4 kg	18(9%)	7.0(7.0%)	25(8.0%)
1/2 kg	54(27%)	30(30%)	84(28%)
1.0 kg	128(64%)	63(63%)	191(64%)
Other quantity	0.0(0.0%)	0.0(0.0%)	0.0(0.0%)
Total	200(100%)	100(100%)	300(100%)

Table 21: Those carrying out measures to reduce pesticide residues from food commodities.

	Males	Females	Total
UAE Nationals	19(95%)	171(95%)	190(95%)
Other Nationalities	60(94%)	26(72%)	86(86%)
Total	79(94%)	197(91%)	276(92%)

Table 22a: The order and importance of measures performed to reduce pesticide residues on produce. (By gender)

	Washing	Peeling	Both Washing and Peeling	Total
Males	14(17%)	0.0(0.0%)	70(83%)	84(100%)
Females	30(14%)	0.0(0.0%)	186(86%)	216(100%)
Total	44(15%)	0.0(0.0%)	256(85%)	300(100%)

Table 22b: The order and importance of measures performed to reduce pesticide residues on produce. (By nationalities)

Nationality	Washing	Peeling	Both washing and peeling	Total
UAE Nationals	34(17%)	0.0(0.0%)	166(83%)	200(100%)
Other Nationalities	10(10%)	0.0(0.0%)	90(90 %)	100(100%)
Total	44(15%)	0.0(0.0%)	256(85%)	300(100%)

Table 23: Indication of the willingness to pay higher prices for pesticide – free commodities among Males and Females for UAE nationals and other nationalities.

	Males	Females	Total
UAE Nationals	17(85%)	65(36%)	82(41%)
Other Nationalities	57(89%)	29(81%)	86(86%)
Total	74(88%)	94(44%)	168(56%)

Table 24: Those who had reservations about locally produced vegetables in males and females in UAE nationals and other nationalities

	Males	Females	Total
UAE Nationals	12(60%)	102(57%)	114(57%)
Other Nationalities	52(81%)	28(78%)	80(80%)
Total	64(76%)	130(60%)	194(65%)

Table 25: The primary sources of information about locally produced commodities indicated by the respondents.

Other people	Newspapers	TV – radio	Scientific evidence	Personal evidence	Total
204(68%)	9.0(3.0%)	3.0(1.0 %)	6.0(2.0%)	78(26%)	300(100%)

Table 26: Those who claimed to have some knowledge about possible effects of pesticide residues.

	Males	Females	Total
UAE Nationals	12(60%)	64(36%)	76(38%)
Other Nationalities	32(50%)	10(28%)	42(42 %)
Total	44(52%)	74(34%)	118(39%)

3.4 DISCUSSION

Table (14) indicated that the number of the UAE nationals in the selected sample was twice that of the other nationalities though the ratio of nationals and non-nationals in the whole population of the UAE is the reverse of this. The reasons for this sampling bias were, that the purchasing power of the nationals and their impact on the economy is double or more than that of the non-nationals. Most of the non-nationals were single (guest workers) who return to their home countries during their annual holidays, and generally shop only for themselves while in the UAE. This point was also reflected by the ratio of males to females in the two categories, (28% males 72% females) as most of the shopping is done by females either directly by the householder or as directed servants.

The same table also showed that the educational status for the individuals surveyed, which was put in three different categories, University Educated 48%, Secondary Educated 34% and Primary Educated or less 18%. The question regarding who did the shopping and where, indicated that 79% do the shopping themselves, 21% by another person. Most of the non-nationals were single people who shop for themselves.

Table (15a) showed that 62% of the total selected sample were concerned about pesticides residues in food commodities, and was similar to the national survey conducted by the food marketing institute in the USA, where approximately 75 percent of the consumers polled said that they were very concerned about pesticides in their food. This was greater than the percentage of customers concerned about cholesterol, fats, salt, additives, or any other food component, (Tweedy *et al.,* 1991).

Generally males showed a greater level of concern than did females and that may be because many of the females surveyed were single and not concerned about family health issues. Also the age and educational status may be influencing factors with 88% of the females being less than 30 years of age and 62% of them with secondary education or less. The higher level of concern in non UAE-nationals may be influenced by the higher level of education achieved by those surveyed in this group.

The data in table (15b) showed that 68% of those who were concerned gave reasons for their concern. These reasons included, that pesticides may cause cancer, may be responsible for birth defects and cause direct health problems.

The data in tables (15c & d) indicate that the level of concern was greater in adults above 30 years of age and this may be directly related to the level of education (being greatest in university educated people) indicating that a higher level of awareness of such issues was prominent in this group.

The data in table (16) indicated that concern about pesticide residues in fresh fruits and vegetables ranked first relative to other selected food commodities (69%) while baby food came second (31%) and fruit juices last. It would appear that un-processed foods are seen as the greatest risk to personal health.

The data in table (17a) illustrated the effects of nationality and gender on level of concern about the origin of fresh vegetables. It seems that, males in both categories (UAE nationals and other nationalities) showed greater concern about the origin of food commodities (70 & 79 percent respectively) with females in both categories showing less concern (58 & 44 percent respectively).

Although the level of concern was greatest amongst males, it is important to note that for nationals of the UAE, shopping is generally conducted (direct or directed) by females.

The data in table (17b) indicated that males were more likely to give reasons for their concerns about pesticide residues in food.

Some of the reasons given were:

1 A Perception that locally produced foods contained higher levels of pesticides and fertilizers than foods from foreign countries.

2 Preference for " Organic " produce.

3 Perception that some countries (Pakistan, India, Indonesia & Iran) still use harsh, harmful pesticides such as DDT, whereas other countries such as those in the EEC have regulations, which prevent the use of such chemicals.

The data in tables (17c & d) showed that the concern about the origin of the selected vegetables (tomato and cucumber) was greatest amongst the adults above 30 years 91% and amongst those with a university education 93%.

The data in tables (18a & b), (19a & b) and (20a & b) illustrate the comparative rates of consumption of tomato and cucumber. It was shown that more tomatoes were consumed than cucumber with 64% of the population consuming one kilogram per person per week; while for cucumber 43% of the population consume 1 kilogram per person per week. This result illustrates the cultural food consumption habits of the population. Tomatoes are used more frequently (in cooked food, as a salad component and for juicing) than cucumbers which are used more frequently in salad only.

It appears that the consumption of tomatoes in the UAE (per person per week) is almost double the consumption levels in Australia (which is approximately ½ kg per person per week according to the Australian Bureau of Statistics, 2000). This result leads to an important point, that standards (MRLs) for pesticide residues in products should not be adapted from other countries without first taking into consideration relative differences in food consumption patterns. With twice the Australian consumption rate for tomatoes occurring in the UAE, one could suggest that MRLs should be halved to maintain similar Average Daily Intake (ADI) levels for contaminating pesticides.

The date in tables (21) and (22a & b) illustrated the measures taken to reduce the effects of pesticide residues on food commodities. They show that 94% and 91% of males and females respectively routinely perform measures to reduce pesticide residues indicating a substantial level of awareness among the individuals sampled. It is interesting that the majority of the sample used both washing and peeling as measures to reduce pesticide residues. The concern about pesticide residue effects was also indicated in table (23) where 88% and 44% of males and females respectively (56% as a total) showed a readiness to pay higher prices for pesticide- free commodities. This willingness was greatest in males and was possibly influenced by the fact that most of the females surveyed were single and not shopping for a family unit. These results indirectly support a similar survey of Atlanta shoppers which found that 61.5% of shoppers would be willing to accept more cosmetic defects to ensure pesticide-free produce (Muir, 1998).

Also, the level of concern regarding the specific safety of locally grown products was slightly higher among males than for females for both UAE nationals and non-nationals with the overall level of concern being higher for non-nationals (Table 24).

The data in table (25) outlines the sources of information influencing the public on food safety issues. The table indicated that 68% of the sample showed that their primary source of information was from other people followed by personal evidence (26%) while reliance on media sources was substantially low. The public perception is that locally produced vegetables contained higher levels of pesticides than did imported produce. Such perceptions are mainly spread through personal discussion.

Some of the examples of personal evidence given by the survey respondents included:

1 Bad agriculture practices and overuse of pesticides and chemical fertilizers being common in the UAE.
2 A General lack of trust in the ability of the authorities to protect the consumer from such hazards.

Table (26) showed that knowledge about the possible effects of pesticide residues among the sample categories was poor. This result indicated that the role-played by media in this respect needs to be revised and strengthened. The examples of knowledge as indicated from the survey, included a general perception that pesticides may affect health (e.g. liver functions), or that they may influence the rates of birth defects and cancers.

3.5 CONCLUSION

From the obtained information's and results, it can be said that:

1. Generally, there is a substantial level of concern about pesticide residues in food commodities among the UAE consumers.
2. Males showed a greater level of concern than females did on this issue.
3. The level of concern about pesticide residues in food commodities was greater among adults above 30 years of age than those of younger age.
4. The level of education achieved by individuals surveyed appears to be correlated with their level of awareness of pesticide residue issues.
5. Generally most of the consumers placed fresh fruit and vegetables at a high priority concerning the issue of pesticide contamination of food.
6. Generally it seems that the country of origin is important to UAE consumers.
7. Generally in the UAE the consumption of tomato is greater than that for cucumber.
8. It seems that the per capita consumption of tomatoes in the United Arab Emirates is higher (double) than in Australia.
9. It seems that the awareness of pesticide issues in food among UAE consumers results in, most of them carrying out some measures to reduce pesticide residues on food commodities.
10. There is a reasonable percentage of UAE consumers who are willing to pay higher prices for pesticide-free commodities.
11. Males showed a higher level of reservation about locally produced vegetables than females did.
12. It appears that the role of the media such issues is perceived as weak, and needs to be strengthened.
13. There is an urgent need for local standards for pesticide useage, on different food commodities which should take into consider the local

consumers behavior and consumption patterns for different food commodities.

14. New regulations need to be developed, applied and promoted to guarantee food safety and to restore consumer confidence in locally produced fruit and vegetable crops.

4.0 MATERIALS AND METHODS

4.1 MATERIALS

4.1.1 PESTICIDES

Certain pesticides were selected for the purpose of this study according to the importance of their use in the UAE for controlling the major pests and diseases, which attack tomato and cucumber. Those selected were diazinon, dimethoate, chlorpyrifos, chlorothalonil, and metalaxyl. Their chemical and physical properties are as follows:

Diazinon

Diazinon is a non-systemic organophosphate insecticide and acaricide with contact, stomach and respiratory action. Used to control sucking and chewing insects and mites on a very wide range of crops, including vegetables, fruit trees. It is used on rice, sugarcane, corn, tobacco, and nematodes in turf; seed treatment and fly control. It is also has veterinary uses against fleas and ticks. (Timlon 2000).

A. Properties

Clear liquid, completely miscible with common organic solvents. Susceptible to oxidation above 100°C. Stable in neutral media, but hydrolysed in alkaline media and more rapidly in acidic media. (Timlon 2000)

B. Composition

O, O-diethyl-O- (2-isopropyle-6-methyl-4-pyrimidinyl) phosphorothioate.

C. Structure

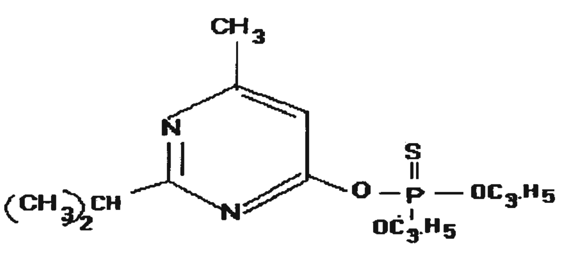


Figure (1): Diazinon Structure

Dimethoate

It is an organophosphate insecticide used as systemic insecticides and acaricides with contact and stomach action. It is used against a variety of insects like aphids, thrips, plant hoppers, and white flies on ornamental plants, forage crops, apples, grapefruit, grapes and many other crops.

A. Properties

White crystalline solid, mercaptan odor, the melting point between 45-48°C. Highly soluable in chloroform, methylene chloride, benzene, toluene, and alcohols (Farm Chemical, 2000).

B. Composition

O, O-dimethyl S-methyl carbamoyl methyl Phosphorodithioate.

C. Structure

$$CH_3NHCOCH_2-S-\overset{\overset{\large S}{\|}}{P}-(OCH_3)_2$$

Figure (2): Dimethoate Structure

Chlorpyrifos

Non-systemic insecticide with contact, stomach and respiratory action. Used for the control of Coleoptera, Diptera and Lepidoptera on vegetables, strawberry, nut crops and soil (Timlon 2000).

A. Properties

Colorless crystals, with a mild mercaptan odour. Soluable in most organic solvents, e.g., acetone, benzene, chloroform and diethyl ether (Timlon 2000).

B. Composition

O, O-diethyl O- (3,5,6-Trichloro-2-Pyridinyl) phosphorothioate.

C. Structure

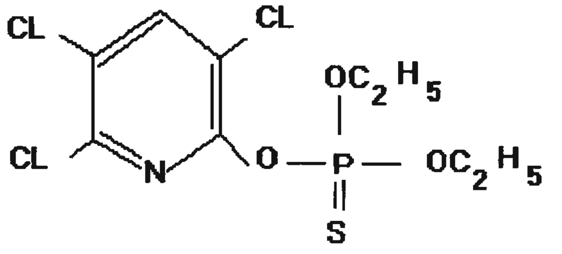


Figure (3): Chlorpyrifos Structure

Chlorothalonil

It is classified as a general use pesticide (GUP) by the EPA and belongs to the chemical class chloronitrile. It is classified as toxicity class II, moderately toxic, due to its potential for eye irritation. It is a broad spectrum organochlorine fungicide used to control fungi attacking vegetables, trees, small fruits, turf, ornamentals, and other agricultural crops.

A. Properties

The technical ingredient is a white crystalline solid. Melting point 250 - 251°C. Stable to ultraviolet radiation in neutral or acidic aqueous media. It is also thermally stable under normal storage conditions. Odorless in its pure form. Nonvolatile under normal field conditions. (Farm Chemical, 2000).

B. Composition

Tetrachloroisophthalonitrile.

C. Structure

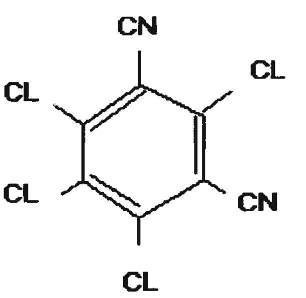


Figure (4): Chlorothalonil Structure

Metalaxyl

Metalaxyl is a systemic fungicide with protective and curative action, absorbed through leaves, stems and roots. Used as foliar sprays, as a soil treatment for control of soil-borne pathogens, and as a seed dressing to control air-borne diseases on tomatoes and different crops (Timlon 2000).

A. Properties

Fine, white powder, soluable in acetone, ethanol, toluene and hexane (Timlon 2000).

B. Composition

N- (2,6-dimethylphenyl)-N (methoxyacetyl)-DL-alaninemethylester.

C. Structure

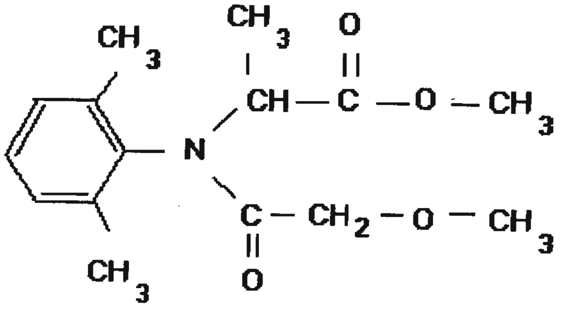


Figure (5): Metalaxyl Structure

4.1.2 COLLECTION OF SAMPLES

Samples of cucumber and tomato were collected from retail markets in both Australia and the United Arab Emirates according to the selected set out in the tables below.

The collected samples weighed between 2 and 5 kg (7 to 12 units) each. This sample size is in agreement with the FAO (1984) recommended method of sampling for the determination of pesticide residues. The samples were collected in a random manner to ensure that they were representative of the whole population from which it was taken. The samples were collected from different markets in different cities in the UAE, but most of the local samples originated from the two major agricultural areas (Al-Ain and Liwa) while in Australia, the samples were collected from the Brisbane wholesale market and originated from production areas, including Laidley, Bowen and Bundaberg.

Australian Samples

Table (27) shows the Australian samples, which were collected from the market place in Brisbane.

Table 27: Australian samples.

	Tomato		**Cucumber**	
Collection date	Origin of sample	No. Of samples	Origin of sample	No. Of samples
16 /11/ 1999	Brisbane	1	Laidley	1
24 /11/ 1999	Brisbane	---	Laidley	1
01 / 12 / 1999	Brisbane	3	Laidley	2
20 /12 / 1999	Bowen	2	------	-----
20 /12 / 1999	Brisbane	1	------	-----
20 / 12 /1999	Bundaberg	2	-------	-----
Total		*9*		*4*

The UAE Samples

As the market in the UAE is open to international trade Table (28) indicates that some samples originated from neighboring countries including Jordan and Oman.

Table 28: UAE Samples.

	Tomato		Cucumber	
Collection date	Origin of sample	No. Of samples	Origin of sample	No. Of samples
19 / 04 / 2000	UAE	1	UAE	3
29 /04 / 2000	UAE	4	UAE	3
01 / 05 / 2000	Jordan	2	Liwa (UAE)	2
16 / 05 / 2000	Oman	2	AL-Ain (UAE)	2
16 / 05 / 2000	Jordan	2	Liwa (UAE)	2
29 / 05 /2000	Oman	2	Oman	1
29 / 05 / 2000	UAE	2	AL-Ain (UAE)	4
20 / 06 / 2000	UAE	6	UAE	2
20 / 06 / 2000	Oman	2	Oman	5
11 / 07 / 2000	Jordan	2	------	--
11 / 07 / 2000	UAE	3	UAE	2
01 / 10 / 2000	Jordan	2	Oman	2
01 / 10 / 2000	UAE	2	UAE	2
Total		*32*		*30*

4.1.3 REAGENTS

Solvents & solutions

1- Petroleum ether, acetone, methanol, and dichloromethane. All of these solvents were of pesticide residue analysis grade.

2- Deionised water (filter 50 μm).

3- Saturated sodium chloride solution.

Salts

1- Sodium sulphate anhydrous AR, fired at 550°C.

2- 5 % Deactivated florisil (GCL – QPM – 200).

Standard references

All active ingredients of Diazinon, Dimethoate, Chlorothalonil, Chlorpyrifos and Metalaxyl were of purity between 95 % to 99 %, and were used for standard solutions and spiking samples for percentage recovery work.

4.1.4 APPARATUS

1- Macro glass chromatography column, at 20 mm id fitted with a sintered

Glass disc and Teflon tap.

2- Food processor.

3- Blender.

4- Rotary evaporator with water bath kept at 45 – 50°C.

5- Orbital shaker.

6- Controlled temperature hotplate (50°C) equipped with a nitrogen blow-down system.

7- Appropriate glassware, pre-rinsed with acetone.

4.1.5 EQUIPMENT

In Australia

A Shimadzu GC-17A (Japan) Gas chromatograph equipped with electron capture detector (ECD).

Dual columns

Channel 1 J&W DB 1701 30m by 0.25mm.

Channel 2 J&W DB5 30m by 0.25mm.

Initial Temp 140°C for 1 min.

Then 17.8° C /min for 9.4 min to 240°C

Total time 16.02 min.

B HP/ Gas chromatograph equipped with nitrogen phosphorus detector (NPD).

Column J & W DB 35 30m by 0.32 mm.

Initial temp 50°C for 1 min.

Then 20°C /min to 260°C for 10 min.

Then hold -total time 21.5 min.

In the UAE

A Gas chromatograph equipped with electron capture detector (ECD).

Trade name: HP 6890 (USA).

Column:

Producer Company: Supleco

Stationary phase: SPB-608

Type: Capillary column

Length: 30 m

O.D: 0.25 mm

Film: 0.25 μm

Col oven: Temp program

125°C (2min) to 275°C (10min) by 5°C/min.

Detector: ECD 300°C.

Carrier gas: He 12 Psi. Total flow 4.1 ml / min. anode gas N 6 ml / min.

Injector: 150°C to 175°C by (2.5°C/ min) for 5.0 min, then to 275°C by (4.0°C / min) for 10 min.

Split mode: split ratio 2:1, split flow 1.4 ml / min.

Signals: data rate 50 Hz, minimum peak width 0.004 min.

B Gas chromatograph equipped with nitrogen phosphorus detector (NPD).

Trade name: Varian 3800 (Japan).

Column:

Producer Company: Supleco

Stationary phase: PTE – 5

Type: Capillary column

Length: 30 m

O.D: 0.25 mm

Film: 0.25μm

Col oven: Temp program

50°C (0.5 min) to 100°C (0.5 min) by 100°C /min to 210°C (1 min) by 40°C /min then to 220°C by 1.5°C, finally to 300°C (1.67) by 30°C (Total 67 min).

Detector:

Type: NPD (T – S – D).

Current bead: 3 – 300 A.

Range: 12

Carrier Gas: Helium = 7 psi (7.5 min) to 9.5 psi (9.5 min) by 0.05 psi/min

Injector:

175°C – 275°C (4.5) by 200 c /min then to 150°C (57) by 250°C /min

Split less injection 0 – 1 min

Split injection ratio = 3 at 1.01

4.2 METHODS

The procedure for screening fruit and vegetable samples for pesticides residues by Cheng and Dennison (1999) was adopted for this study.

4.2.1 STANDARD SOLUTIONS

In Australia

A mixture of the five pesticides was prepared by dissolving the following amounts of each compound in a 1 L volumetric flask in acetone which was repeated also using Petroleum Ether:

Dimethoate (0.904 mg), Diazinon (4.585 mg), Chlorothalonil (0.966 mg), Chlorpyrifos (1.06 mg) and Metalaxyl (6.14 mg).

In the UAE

As in the above method, five pesticides were prepared by dissolving the following amounts of each compound in a 1 L volumetric flask in acetone only:

Dimethoate (2.6452 mg), Chlorpyrifos (3.02022 mg), Chlorothalonil (1.765 mg), Diazinon (1.8988 mg) and Metalaxyl (6.2964 mg).

4.2.2 SAMPLE PREPARATION

The sample preparation was done on the same day of collection to minimize pesticide residue decomposition, therefore, sample were chopped and homogenized using a food processor. Part of the blended sample was kept in the deep freezer as a reference.

4.2.3 EXTRACTION PROCEDURE

A- An accurately weighed (30 gm) amount of the prepared sample was added to 75 ml of acetone and blended for two min. The extract was filtered into a 1L separating funnel.

B- The extracted sample was decanted and the flask is rinsed with 3 x 25 ml volumes of acetone which was combined to the acetone extract.

C- 150 ml of dichloromethane was added to the combined acetone extracts with 25 ml saturated NaCl and the funnel was shaken for two min. Soon after, the solvent layer was dried on sodium sulphate, and collected in a rotary evaporator flask .The aqueous layer was re-extracted with 50 ml of a solvent mixture of acetone/ dichloromethane (1:1 V/V) and then the solvent layer dried on anhydrous sodium sulphate and collected in the rotary evaporator flask.

D- The combined extracts were rotary evaporated to an approximate volume of 10 ml.

4.2.4 CLEAN UP PROCEDURE

In Australia

The florisil column chromatography technique used was as follows:

On 10 g of 5 % deactivated florisil the obtained concentrated extract was cleaned - up using the following eluates:

100 ml of 6 % diethyl ether /Petroleum Ether for chlorpyrifos.

100 ml of 10 % acetone / Petroleum Ether for diazinon and chlorothalonil.

100 ml of 50 % acetone / Petroleum Ether for dimethoate, chlorothalonil and metalaxyl.

The obtained eluates were rotary evaporated to approximately 10 ml and transferred to 15 ml graduated tubes, and then dried down to 2ml under nitrogen.

In the UAE

The clean up was conducted by using the GPC technique as follows:

1- The solvent layer was rotary evaporated to 1ml.
2- Dichloromethane was added to the eluate and the volume made to 5ml.
3- 1ml of sample was injected into the GPC.
4- The fraction was collected from the GPC in a rotary evaporator flask and rotary evaporated near drying.
5- 5ml of acetone was added and rotary evaporated near drying

6- Acetone was added to make up the volume to 1ml (nitrogen was used when need to concentrate the eluates to the right volume (1ml) and the sample was injected into the GC.

Instrument: Waters 515 HPLC pump (binary HPG system).
717 plus auto-sampler with 2500 ul loop and syringe.
Detector: UV / VIS –486 tunnel absorbance detector.
Column: Envirogel (Waters) 150 *19 mm id and 300 * 19 mm id.
Waters fraction collector, Auto- Programmable.
Mobile phase: Dichloromethane 3 ml / min.

4.2.5 RECOVERY TRIALS

For testing the accuracy and reliability and validity of the method used, control samples were spiked with known concentrations of the pesticides under investigation.

Therefore, 2 ml (in Australia) and 5 ml (in the UAE) of a standard mixture of diazinon, dimethoate, chlorpyrifos, metalaxyl and chlorothalonil was added to either tomato or cucumber samples.

These recovery trials were carried out at different intervals during this study in order to assure the accuracy and validity of this used method as follows:

In Australia
Six spikes were carried out in parallel with the survey samples.

In The UAE
Seven spikes were carried out in parallel with the survey samples.

4.2.6 CALCULATION METHOD

Concentration of analyte mg/kg = (sample peak height /standard peak height) x conc. of standard (mg/L) x (final volume/ weight of sample)

5.0 RESULTS

The use of pesticides in plant protection programs has resulted in public concern about the level of pesticide residues in food commodities. Therefore, many attempts have been conducted to investigate these problems.

In the UAE, the green revolution under His Highness Shiekh Zayed Ben Sultan AL-Nahyan has widely increased the area of cultivated land, as a result of this, pesticide use has increased. Thus, this preliminary market basket survey has been designed in order to evaluate the actual levels of pesticide residues in imported and local vegetables in the UAE markets, and to compare these with levels from Australian markets.

5.1 RECOVERY RESULT

In order to obtain reasonable and accurate results, a recovery test was conducted. This was done by adding a known amount of the test pesticides to vegetable samples, which were processed and analyzed for recovery. This recovery was carried out alongside the studies in Australia and the UAE to confirm the validity of the results obtained.

5.1.1 RECOVERY TEST IN AUSTRALIA

Six spiked samples, (three tomatoes and three cucumbers) were assessed for pesticide content using both GC-NPD and GC-ECD as shown in Tables 29 and 30 following the method of Cheng and Dennison (1999).

Table 29: The recovery percentage of tested pesticides in Tomato in Australia.

GC Method	Pesticide	Recovery % for each sample			Average Recovery %
		1	2	3	
NPD	Chlorpyrifos	108.6	107.7	94.5	103.6
ECD Column1	Chlorpyrifos	128	127.8	112.7	122.6
ECD Column 2	Chlorpyrifos	99.3	98.7	114	103.7
NPD	Diazinon	112	125	94.8	110.6
ECD Column1	Diazinon	83.2	96	75.7	84.9
ECD Column 2	Diazinon	81.3	90.5	77.2	83.0
NPD	Dimethoate	112	113	123.9	116.3
ECD Column1	Dimethoate	111	113	106	110.0
ECD Column 2	Dimethoate	107.7	112	132	117.2
NPD	Metalaxyl	88	98.6	91	92.5
ECD Column1	Chlorothalonil	100.7	109	101.9	103.8
ECD Column 2	Chlorothalonil	87.3	94.4	87	89.5

Table 30: The recovery percentage of tested pesticides in Cucumber in Australia.

GC Method	Pesticide	Recovery % for each sample			Average Recovery %
		1	2	3	
NPD	Chlorpyrifos	119	116	112	115.6
ECD Column1	Chlorpyrifos	103	102	100	101.6
ECD Column 2	Chlorpyrifos	103	103	99.4	101.8
NPD	Diazinon	120	111	108	113.0
ECD Column1	Diazinon	109	100	96	101.6
ECD Column 2	Diazinon	101	91	88	93.3
NPD	Dimethoate	123	90	85	99.33
ECD Column1	Dimethoate	101	82	78	87.0
ECD Column 2	Dimethoate	112	90	85	95.6
NPD	Metalaxyl	113	98	83	98.0
ECD Column1	Chlorothalonil	121	110.5	105.5	112.3
ECD Column 2	Chlorothalonil	112	100	94	102.0

Figures (6) and (7) are the chromatograms of the standard mixture of (Diazinon, Dimethoate, Metalaxyl, Chlorothalonil and Chlorpyrifos) as detected by NPD and ECD analysis respectively in Australia (Queensland Government Chemistry Lab). (Refer to 4.2.1 A)

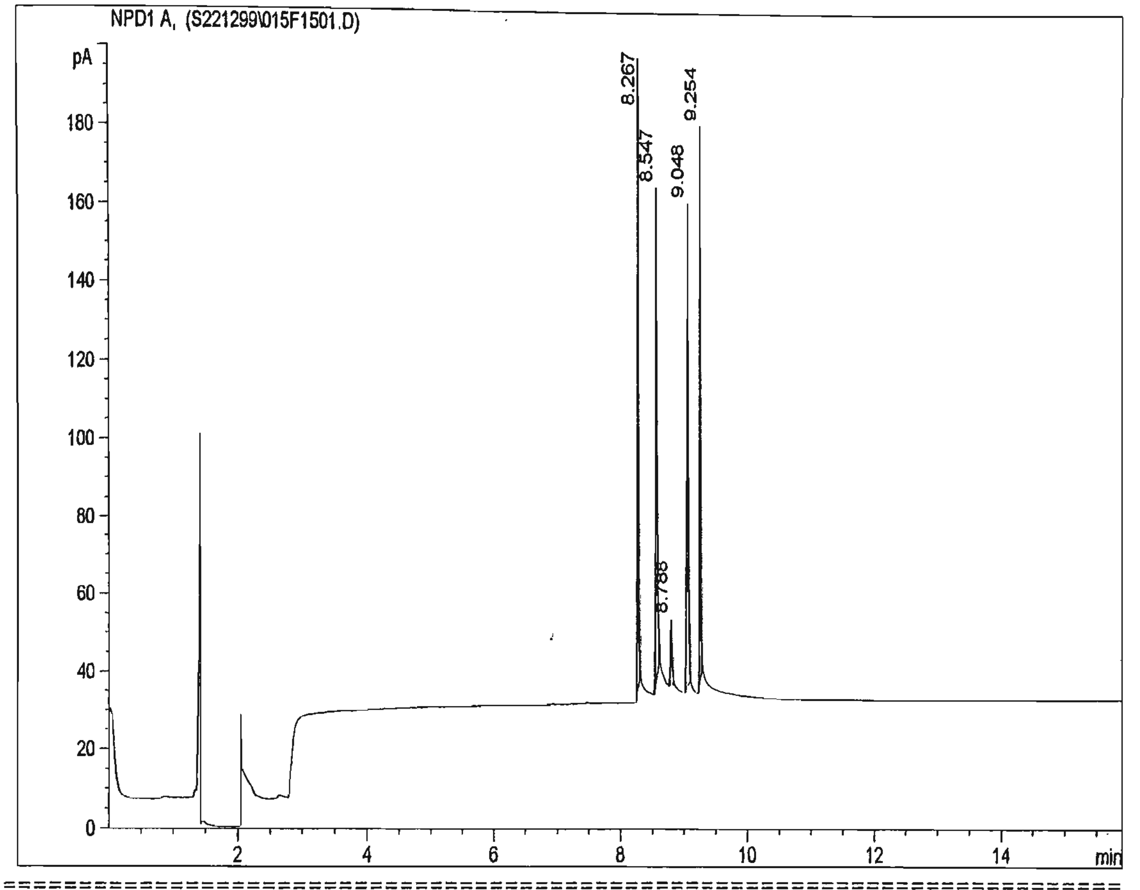
Figures (8) and (9) are a chromatograms of a collected cucumber sample analyzed by NPD and ECD respectively, which was found to be free of detectable levels of pesticides.

A tomato sample analyzed by NPD and ECD respectively showed trace levels of Dimethoate (Figures 10 and 11).

Data file : C:\HPCHEM\1\DATA\S221299\015F1501.D
Sample Name: MIX3 EP

Injection Date :12/22/99 7:22:09 PM
Sample Name :MIX3 EP
Acq Operator :saeed
Acq. Method :SAEEDNPD.M
Analysis Method :C:\HPCHEM\1\METHODS\SAEEDNPD.M

Seq Line : 15
Vial No. : 15
Inj. No. : 1
Inj. Vol. : 3ul



Customized Report:CARTNPD

Signal 1: NPD1 A,

Peak #	RT [min]	Type	Width [min]	Area	Height	Name
1	8.267	PB	0.017	176.871	162.912	Diazinon 8.267
2	8.547	PB	0.022	197.974	127.955	Dimethoate 8.547
3	8.788	PB	0.024	27.340	16.942	Metalaxyl 9.048
4	9.048	PB	0.022	182.123	124.953	Chlorpyrifos 9.254
5	9.254	PB	0.020	189.641	143.147	
6	0.000		0.000	0.000	0.000	
7	0.000		0.000	0.000	0.000	
8	0.000		0.000	0.000	0.000	
9	0.000		0.000	0.000	0.000	
10	0.000		0.000	0.000	0.000	

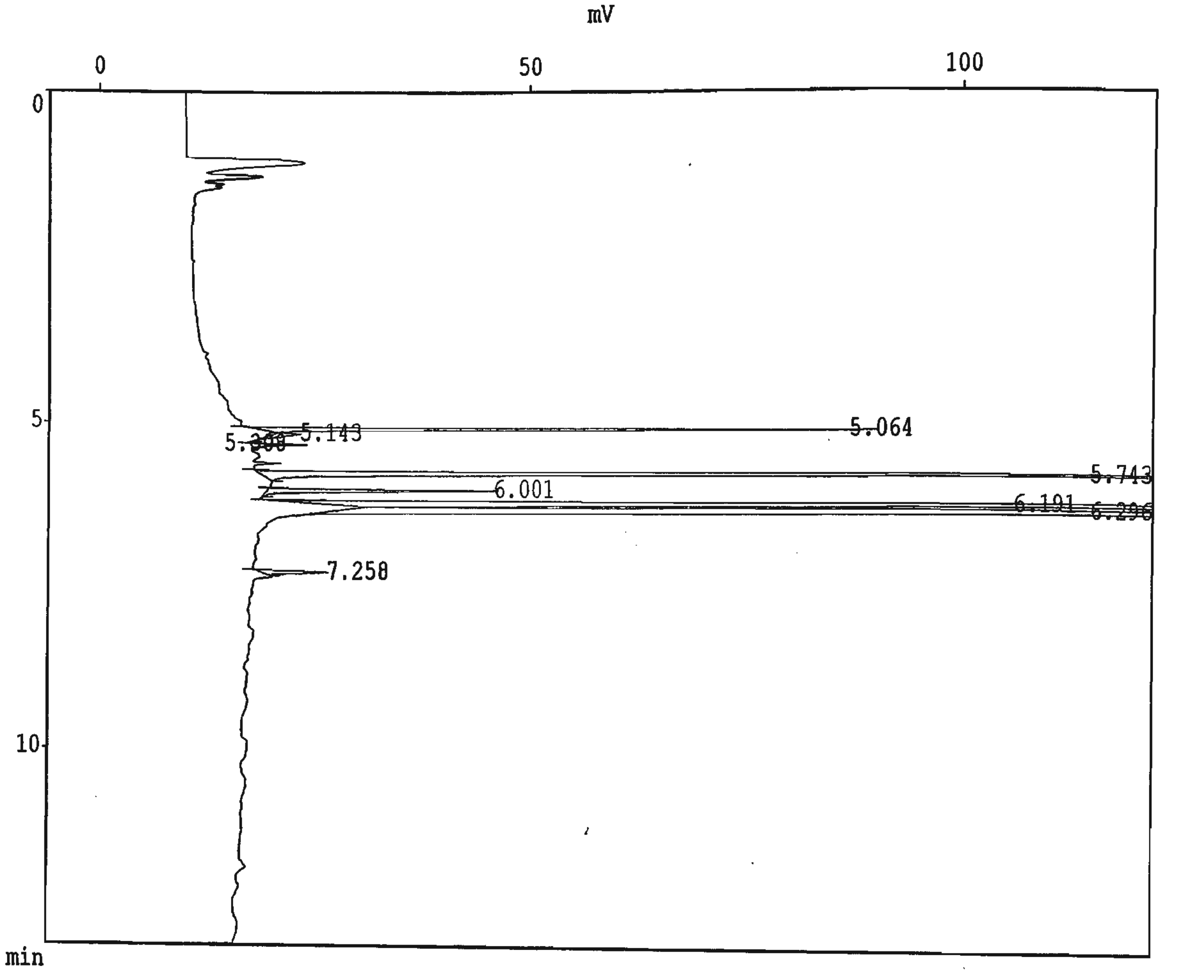
*** End of Report ***

Figure (6): Chromatogram of Standard mixture as detected by NPD, in (AUS).

6890 Wed, 22. Dec. 1999 07:38:05 pm

Ch=1 DATA=S22142.D01 99/12/23 11:11:58
Vial # : 42
Sample : MIX 4 PE
ID :
Method Name : APFAN99.MET

*** Chromatogram *** Filename:S22142.C01



** Peak Report ***

KNO	TIME	HEIGHT	AREA	NAME	CONC [ppb]
1	5.064	72301	123722	Diazinon 5.064	
2	5.143	3061	10525		
3	5.308	6572	12639		
4	5.743	217498	481823	Dimethoate 5.743	
5	6.001	26957	58256		
6	6.191	277169	691047	Chlorothalonil 6.191	
7	6.296	502492	1413176	Chlorpyrifos 6.296	
8	7.258	7903	18230		
		1113955	2809419		

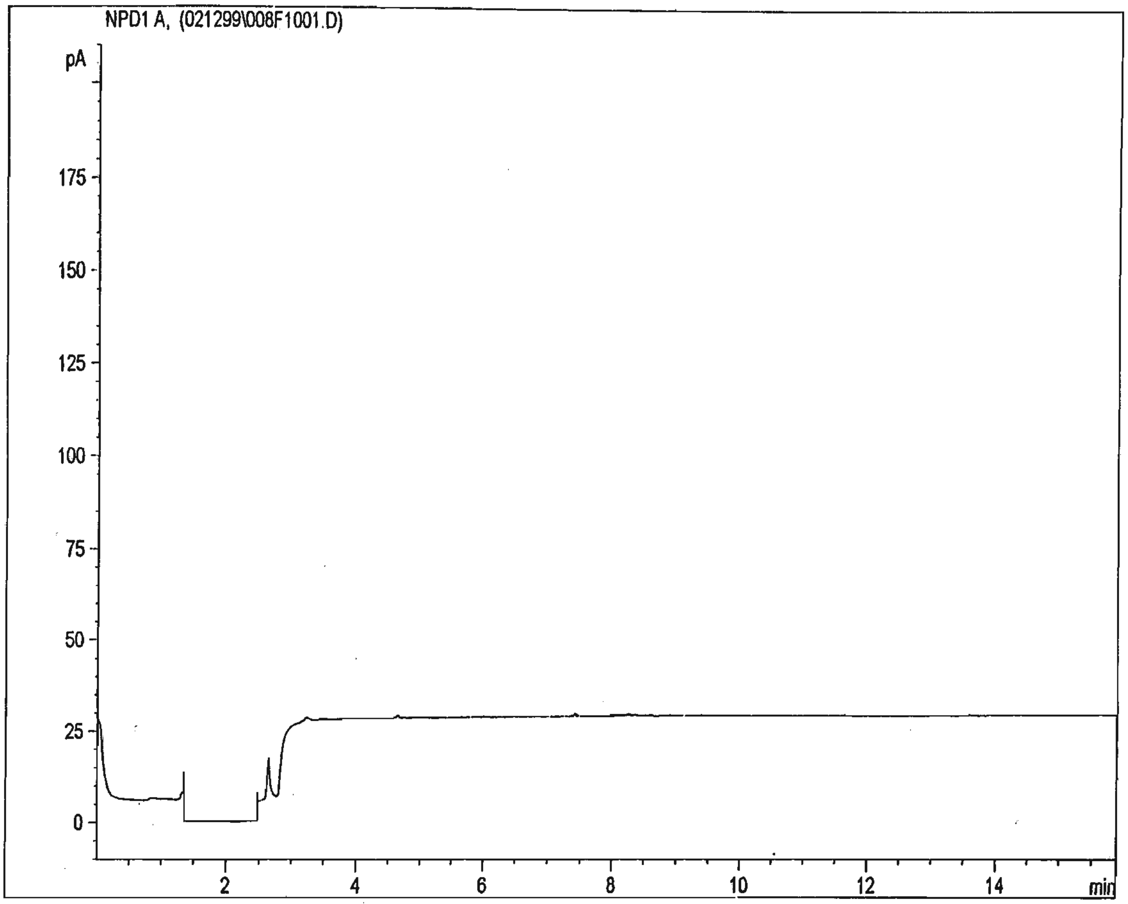
Figure (7): Chromatogram of Standard mixture as detected by ECD, in (AUS).

99/12/23 12:40:51

Sample Name: CUC 1   6%

===

Injection Date	:12/3/99 11:01:09 AM	Seq Line :	10
Sample Name	:CUC 1 6%	Vial No. :	8
Acq Operator	:saeed	Inj No. :	1
Acq. Method	:SAEEDNPD.M	Inj Vol. :	.3ul
Analysis Method	:C:\HPCHEM\1\METHODS\SAEEDNPD.M		



===

Customized Report:CARTNPD

===

Signal 1: NPD1 A,

Peak #	RT [min]	Type	Width [min]	Area	Height	Name
1	0.000		0.000	0.000	0.000	
2	0.000		0.000	0.000	0.000	
3	0.000		0.000	0.000	0.000	
4	0.000		0.000	0.000	0.000	
5	0.000		0.000	0.000	0.000	

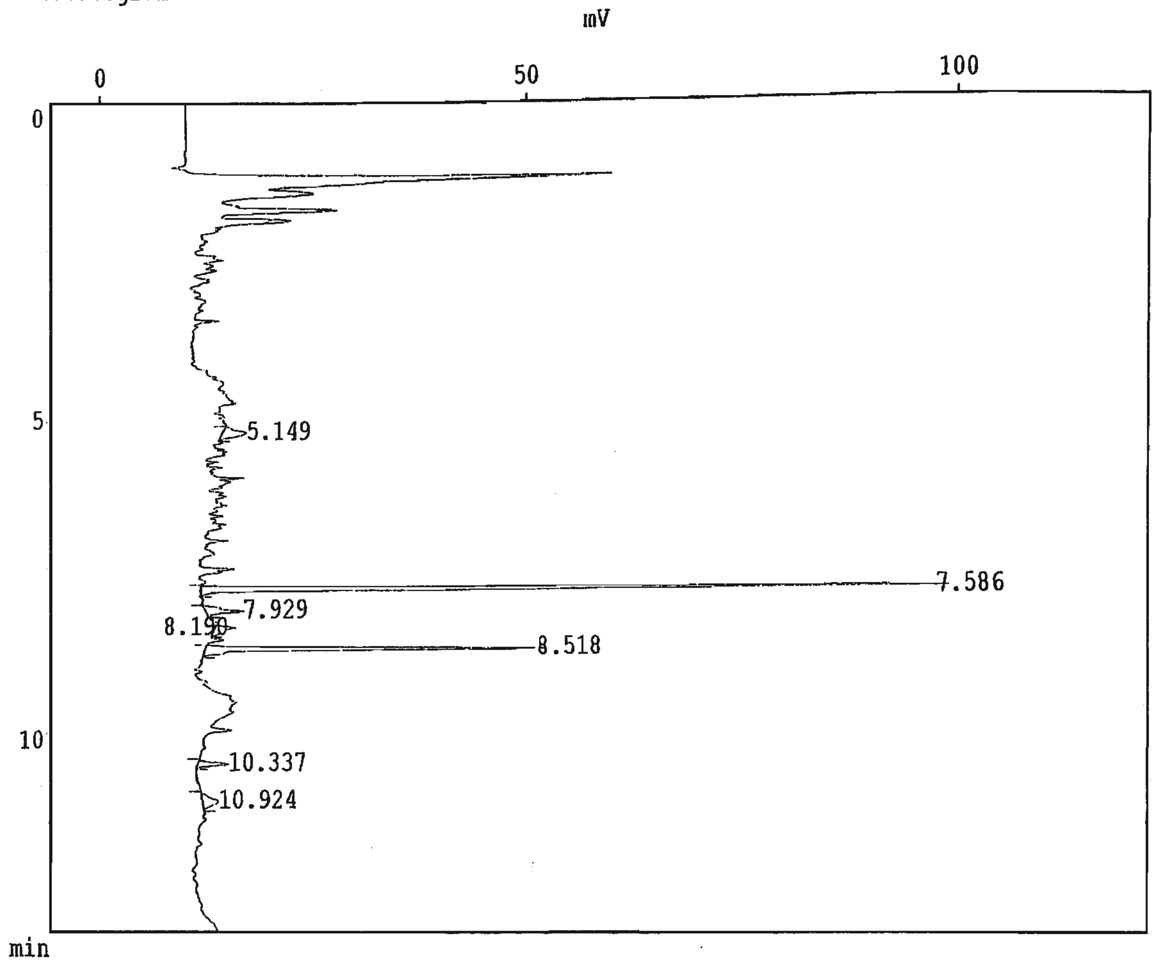
===

*** End of Report ***

Figure (8): Chromatogram of Cucumber sample as detected by NPD, in (AUS).

Ch=1 DATA=S0312136.D01 99/12/04 02:12:10
Vial # : 36
Sample : CUC 1 6%
ID :
Method Filename: APFAN99.MET

*** Chromatogram ***



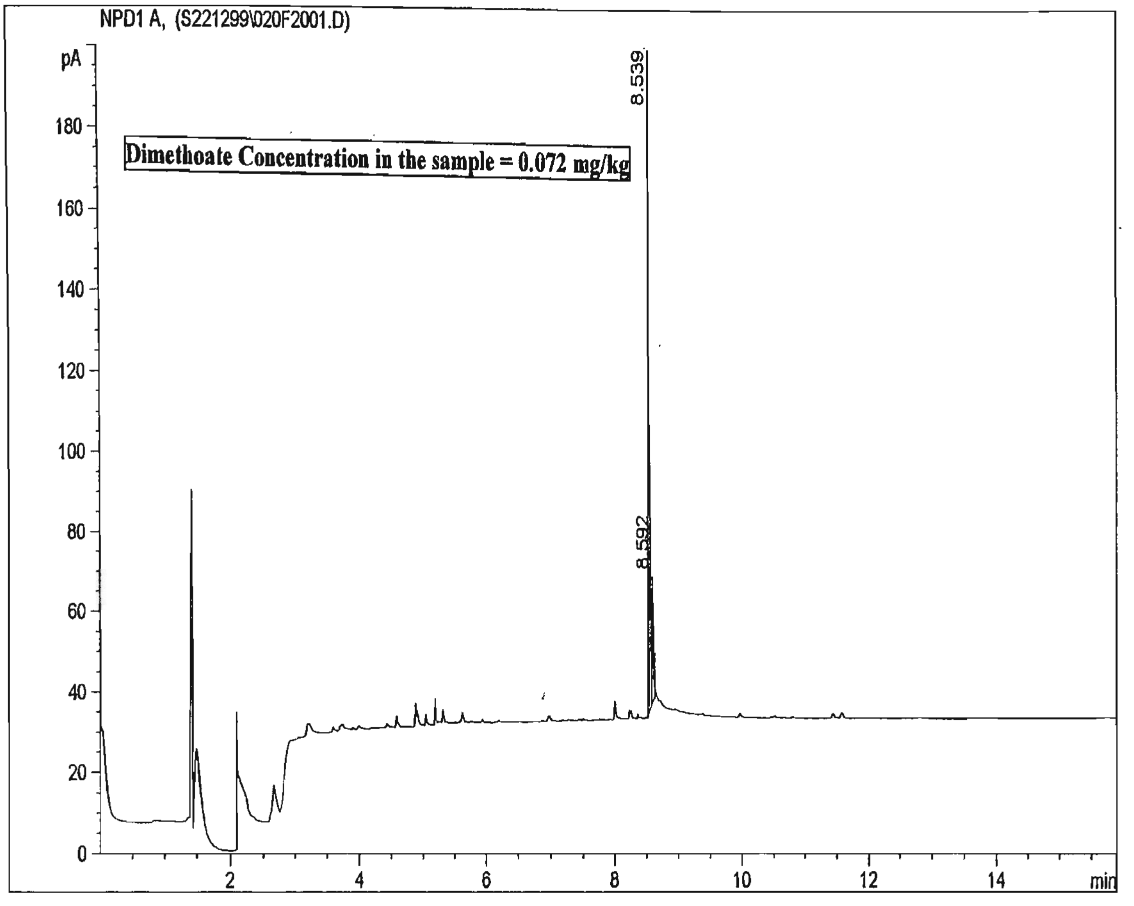
*** Peak Report ***

PKNO	TIME	HEIGHT	AREA	NAME	CONC [ppb]
1	5.149	2724	18215		
2	7.586	87324	217406		
3	7.929	4391	18672		
4	8.190	2316	12578		
5	8.518	39766	113607		
6	10.337	3539	12375		
7	10.924	1840	15900		
		141900	408752		

Figure (9) Chromatogram of Cucumber sample as detected by ECD, in (AUS).

99/12/06 09:19:10

Injection Date	:12/22/99 9:19:45 PM		Seq Line	:	20
Sample Name	:TOM BUND 50%		Vial No.	:	20
Acq Operator	:saeed		Inj. No.	:	1
Acq. Method	:SAEEDNPD.M		Inj. Vol.	:	3ul
Analysis Method	:C:\HPCHEM\1\METHODS\SAEEDNPD.M				



Customized Report:CARTNPD

Signal 1: NPD1 A,

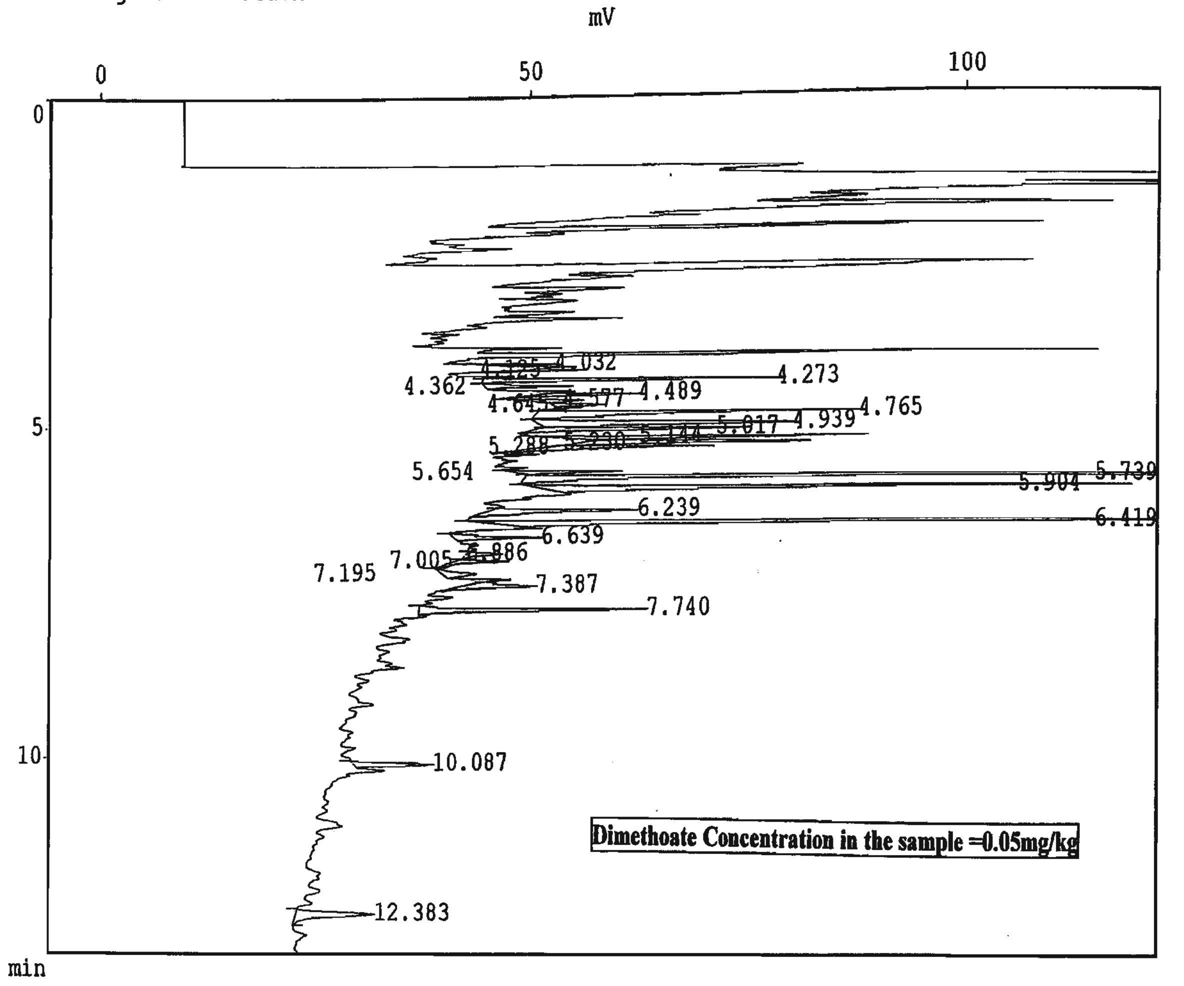
Peak #	RT [min]	Type	Width [min]	Area	Height	Name
1	8.539	PV	0.017	238.308	210.099	Dimethoate 8.539
2	8.592	VB	0.021	45.180	31.766	
3	0.000		0.000	0.000	0.000	
4	0.000		0.000	0.000	0.000	
5	0.000		0.000	0.000	0.000	
6	0.000		0.000	0.000	0.000	
7	0.000		0.000	0.000	0.000	

*** End of Report ***

Figure (10) Chromatogram of Tomato sample as detected by NPD, in (AUS).

CH-1 DATA=S22140.D01 99/12/23 10:32:10
Vial # : 40
Sample : TOM BUNDABEREG
ID : 50%
Method Name : APFAN99.MET

*** Chromatogram *** Filename:S22140.C01



*** Peak Report ***

PKNO	TIME	HEIGHT	AREA	NAME	CONC [ppb]
1	4.032	9347	12960		
2	4.125	8402	11349		
3	4.273	35162	67811		
4	4.362	10309	22730		
5	4.489	11822	21451		
6	4.577	7195	14539		
7	4.645	6042	10647		
8	4.765	37515	103501		
9	4.939	29796	96077		
10	5.017	24845	51835		
11	5.144	35351	72067		
12	5.230	26746	62499		
13	5.288	19333	42367		
14	5.654	12638	24283		
15	5.739	189871	405892	Dimethoate 5.739	
16	5.904	67779	173071		
17	6.239	17653	54493		
18	6.419	122322	257920		
19	6.639	10523	28307		
20	6.886	4273	11319		
21	7.005	6465	17565		
22	7.195	4045	15808		
23	7.387	8787	27906		
24	7.740	26632	72213		
25	10.087	9305	26870		
26	12.383	9251	46079		

Figure (11): Chromatogram of Tomato sample as detected by ECD, in (AUS).

99/12/23 12:40:29

5.1.2 RECOVERY TESTS IN THE UAE

Seven spike samples were carried out at intervals, during the survey, three for tomato and four for cucumber, as shown in Tables 31 and 32.

Table 31: The recovery percentage of tested pesticides in Tomato in the UAE.

GC Method	Pesticide	Recovery % for each sample			Average Recovery %
		1	2	3	
NPD	Chlorpyrifos	103.5	104	95	100.8
ECD	Chlorpyrifos	108	83	85	92.0
NPD	Diazinon	100	111.5	95	102.2
ECD	Diazinon	102	104	85	97.0
NPD	Dimethoate	101	117.5	99	105.8
ECD	Dimethoate	109	98	97	101.3
NPD	Metalaxyl	96	123	112	110.3
ECD	Chlorothalonil	127	103	86	105.5

Table 32: The recovery percentage of tested pesticides in Cucumber in the UAE.

GC Method	Pesticide	Recovery % for each sample				Average Recovery %
		1	2	3	4	
NPD	Chlorpyrifos	100	100	86	73	89.8
ECD	Chlorpyrifos	85	95	75	72	81.8
NPD	Diazinon	111.5	100	79.2	72	90.7
ECD	Diazinon	104	95	86.2	83.2	92.1
NPD	Dimethoate	117.5	109	109.6	94	107.5
ECD	Dimethoate	98	98	115.7	110	105.4
NPD	Metalaxyl	103	114.7	119	108	111.1
ECD	Chlorothalonil	104	114.5	77	80	93.8

Figures (12) and (13) are the chromatograms of the standard mixture of (Diazinon, Dimethoate, Metalaxyl, Chlorothalonil and Chlorpyrifos) as detected by NPD and ECD analysis respectively in the UAE. (Refer 4.2.1 B)

The Cucumber sample in Figure (14) was free of detectable levels of pesticides, used in this study. While the Cucumber in sample figure (15) was contaminated with two pesticides (Dimethoate and Chlorpyrifos) as detected by ECD analysis.

The Tomato sample in Figure (16) was contaminated with Chlorpyrifos as detected by NPD analysis. In addition the Tomato sample in figure (17) contained two pesticide residues, Dimethoate and Chlorpyrifos.

Run File : C:\STAR\SAEED\SAEED_~1\SAM_008.RUN
Method File : C:\STAR\TSD_02.MTH
Sample ID : Mix1new2

Injection Date: 2-MAY-0 3:28 PM   Calculation Date: 2-MAY-0 4:35 PM

Operator :   Detector Type: 3800 (1000 Volts)
Workstation: FECC   Bus Address : 44
Instrument : Varian Star #1   Sample Rate : 10.00 Hz
Channel : Front = TSD   Run Time : 66.932 min

*********** Star Chromatography Workstation ******* Version 4.51 **************

Chart Speed = 0.32 cm/min   Attenuation = 1   Zero Offset = 0%
Start Time = 0.000 min   End Time = 66.932 min   Min / Tick = 5.00

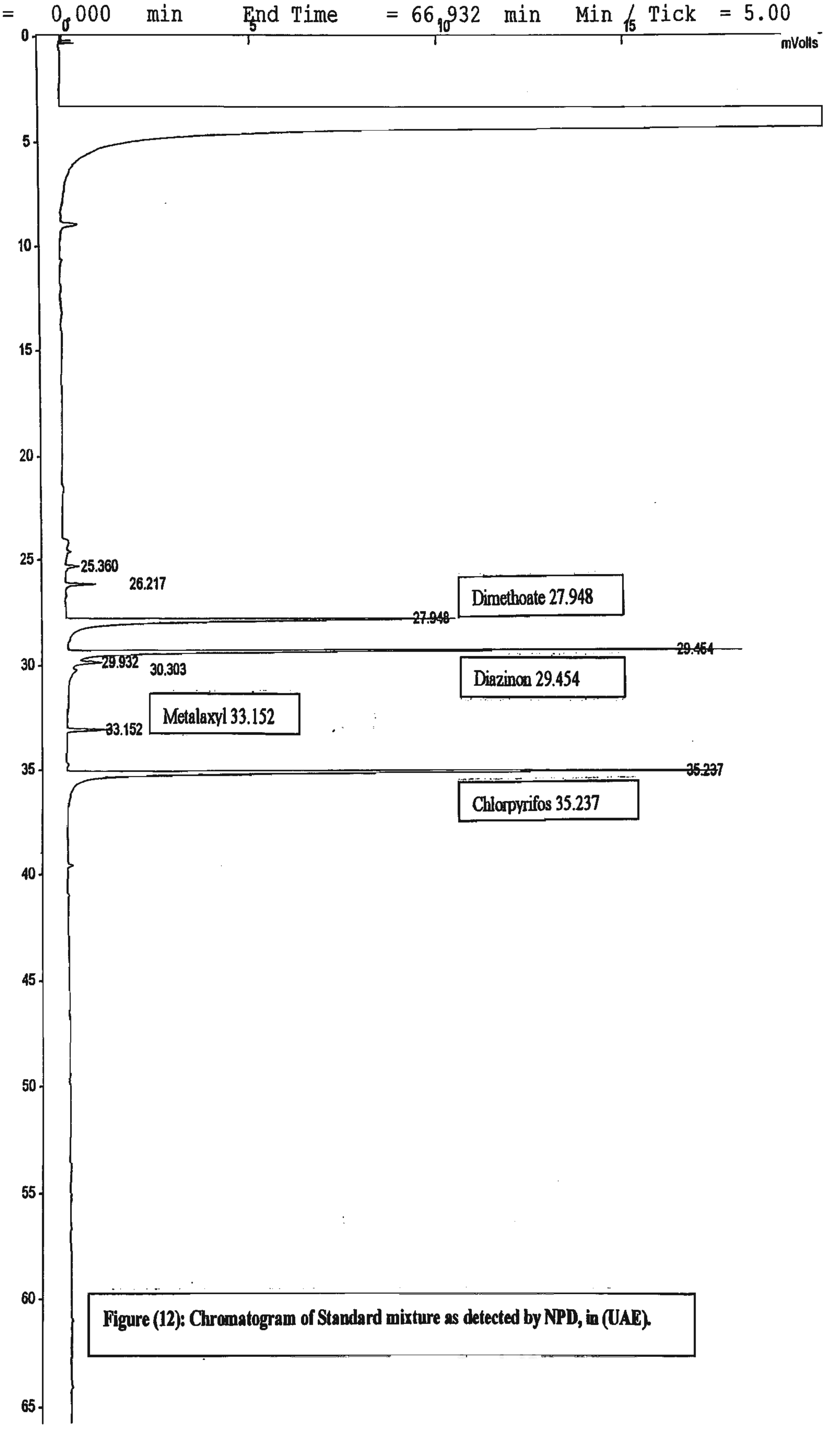
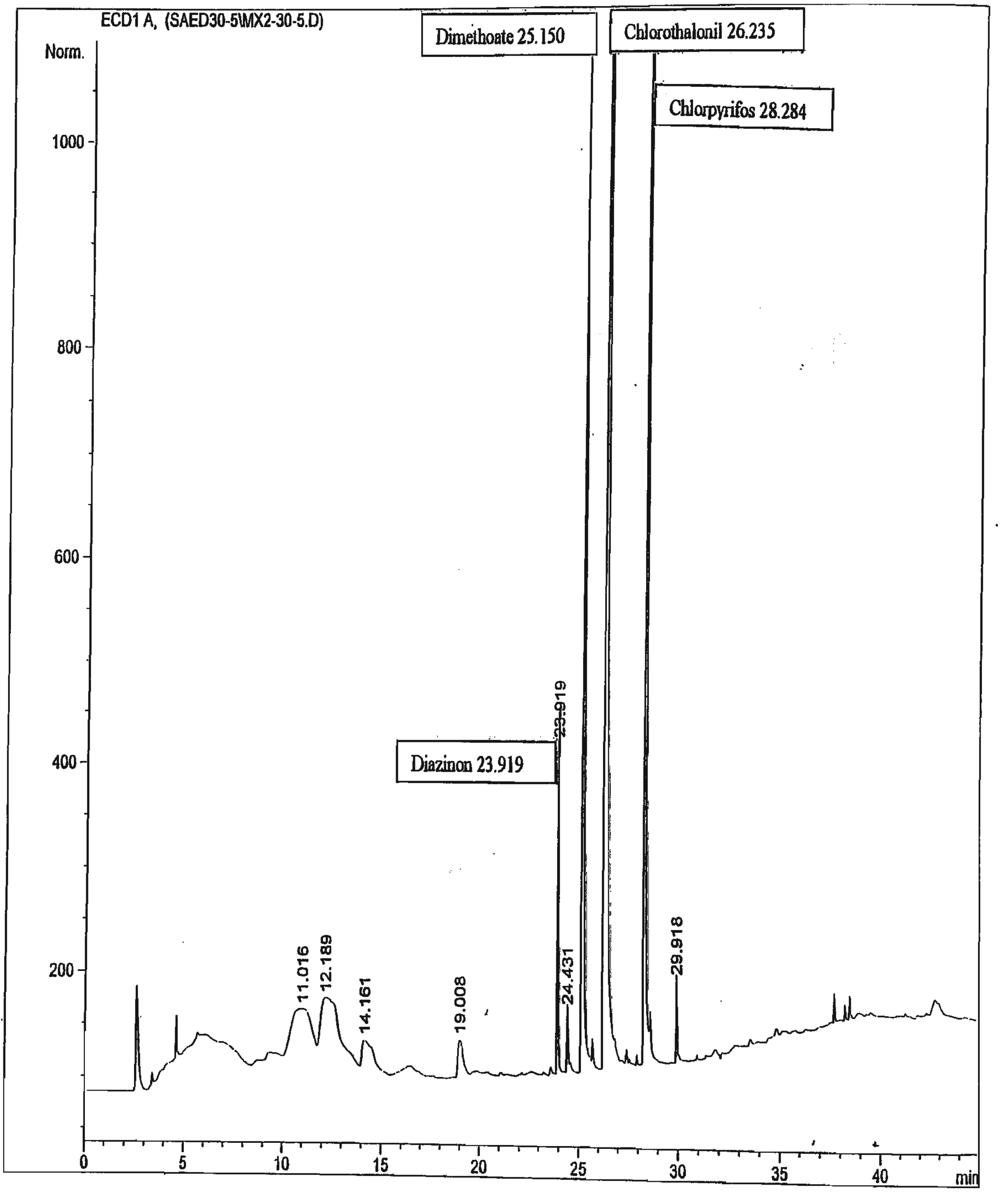


Figure (12): Chromatogram of Standard mixture as detected by NPD, in (UAE).

Data File C:\HPCHEM\1\DATA\SAED30-5\MX2-30-5.D   Sample Name: Mix3-2(30-5)

```
Injection Date  : 5/30/00 5:45:12 PM            Seq. Line :   6
Sample Name     : Mix3-2(30-5)                       Vial :   6
Acq. Operator   : Saeed                               Inj :   1
                                               Inj Volume : 2 µl

Acq. Method     : C:\HPCHEM\1\METHODS\OC.M
Last changed    : 5/1/00 2:29:27 PM
Analysis Method : C:\HPCHEM\1\METHODS\OC.M
Last changed    : 5/31/00 11:42:54 AM by Saeed
                  (modified after loading)
```



Area Percent Report

```
Sorted By       :     Signal
Multiplier      :     1.0000
Dilution        :     1.0000
```

Figure (13): Chromatogram of Standard mixture as detected by ECD, in (UAE).

Run File   : C:\STAR\SAEED\SAEED_~1\SAM_015.RUN
Method File : C:\STAR\TSD_02.MTH
Sample ID   : cuc-L1

Injection Date: 2-MAY-0 11:52 PM   Calculation Date: 3-MAY-0 0:58 AM

Operator   :   Detector Type: 3800 (1000 Volts)
Workstation: FECC   Bus Address : 44
Instrument : Varian Star #1   Sample Rate : 10.00 Hz
Channel   : Front = TSD   Run Time   : 66.932 min

*********** Star Chromatography Workstation ******* Version 4.51 **************

Chart Speed =   0.32 cm/min   Attenuation = 1   Zero Offset = 0%
Start Time =   0.000   min   End Time   = 66.932 min   Min / Tick = 5.00

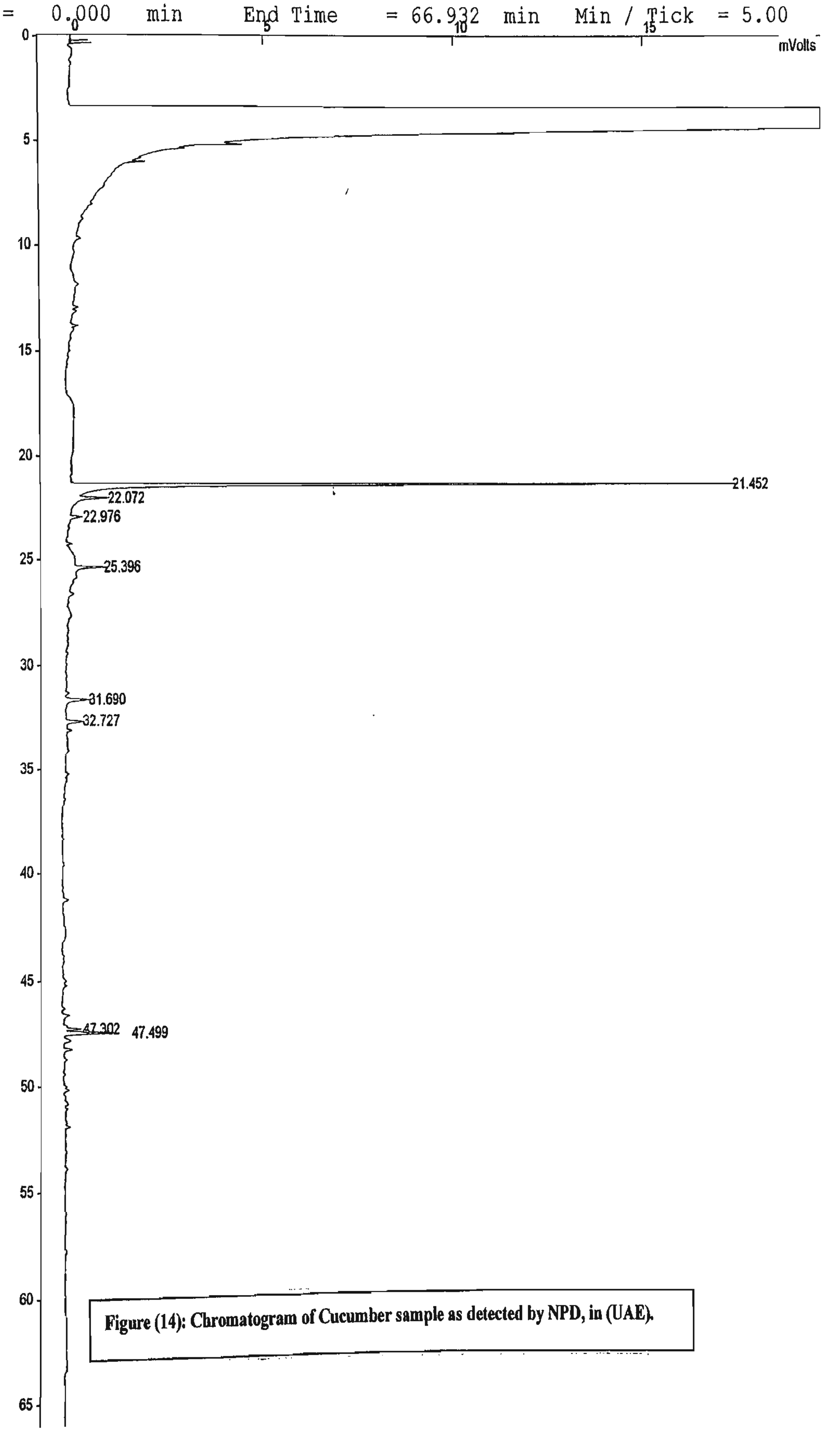
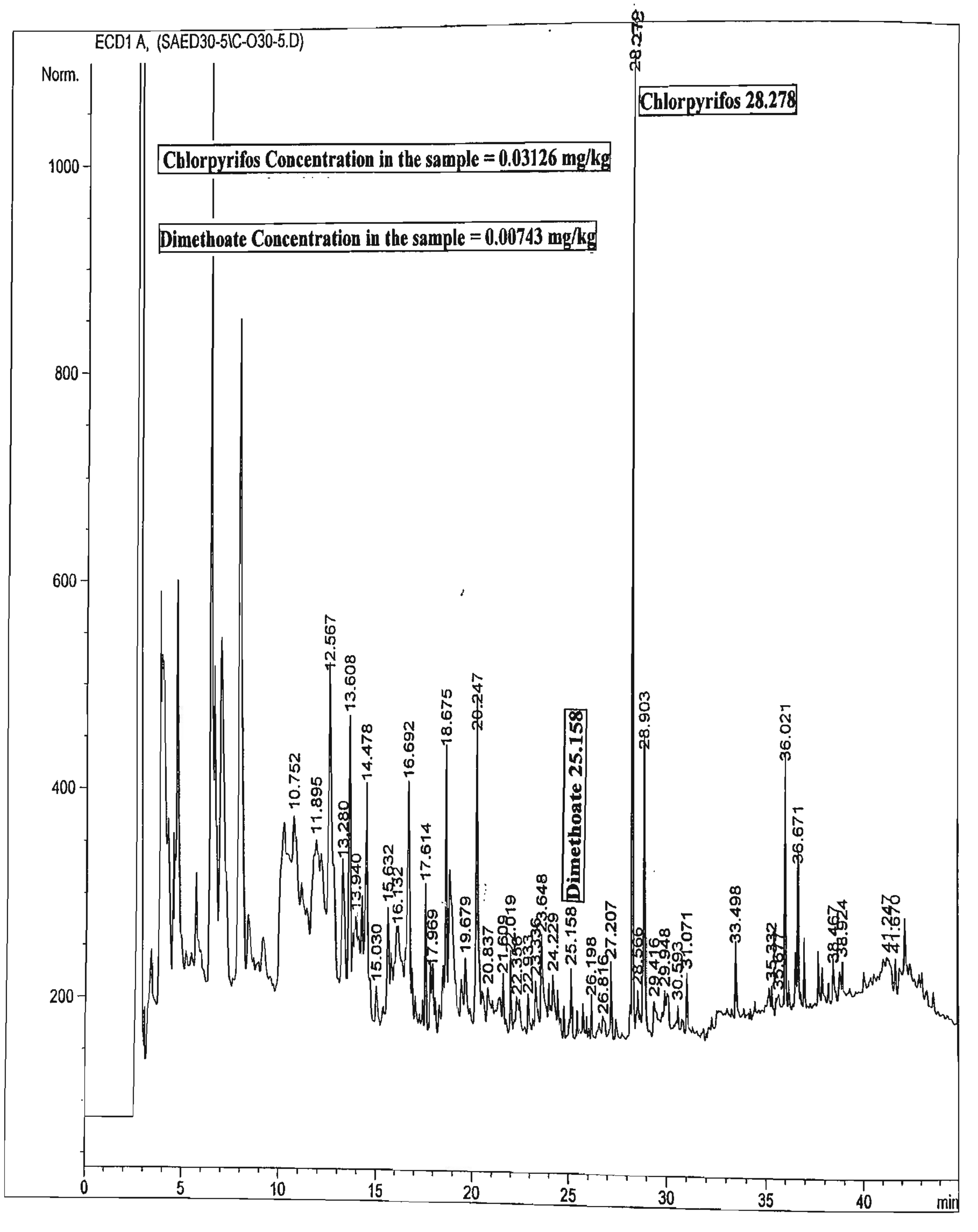


Figure (14): Chromatogram of Cucumber sample as detected by NPD, in (UAE).

Injection Date	: 5/30/00 6:36:19 PM	Seq. Line :	7
Sample Name	: Cuc-Oman-30-5	Vial :	7
Acq. Operator	: Saeed	Inj :	1
		Inj Volume :	2 µl

Acq. Method : C:\HPCHEM\1\METHODS\OC.M
Last changed : 5/1/00 2:29:27 PM
Analysis Method : C:\HPCHEM\1\METHODS\OC.M
Last changed : 5/31/00 11:42:54 AM by Saeed
(modified after loading)



Area Percent Report

Sorted By : Signal
Multiplier : 1.0000
Dilution : 1.0000

Figure (15) Chromatogram of Cucumber sample as detected by ECD, in (UAE).

Run File   : C:\STAR\SAEED\SAEED_~1\SAM_014.RUN
Method File : C:\STAR\TSD_02.MTH
Sample ID   : Tom-Jord-2

Injection Date: 2-MAY-0 10:40 PM   Calculation Date: 2-MAY-0 11:47 PM

Operator   :   Detector Type: 3800 (1000 Volts)
Workstation: FECC   Bus Address   : 44
Instrument : Varian Star #1   Sample Rate   : 10.00 Hz
Channel   : Front = TSD   Run Time   : 66.932 min

*********** Star Chromatography Workstation ******* Version 4.51 **************

Chart Speed =   0.32 cm/min   Attenuation = 1   Zero Offset = 0%
Start Time =   0.000 min   End Time   = 66.932 min   Min / Tick = 5.00

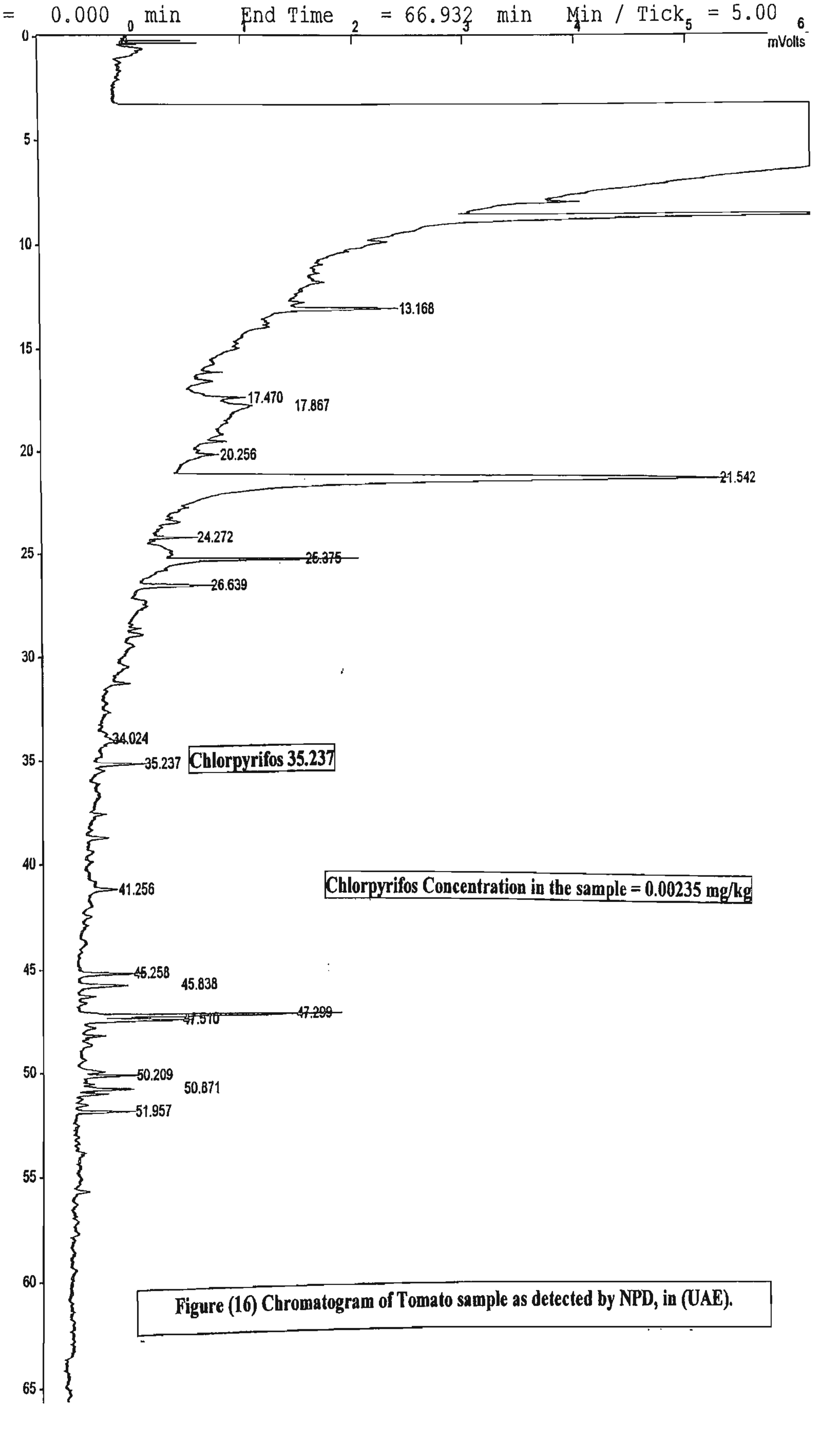


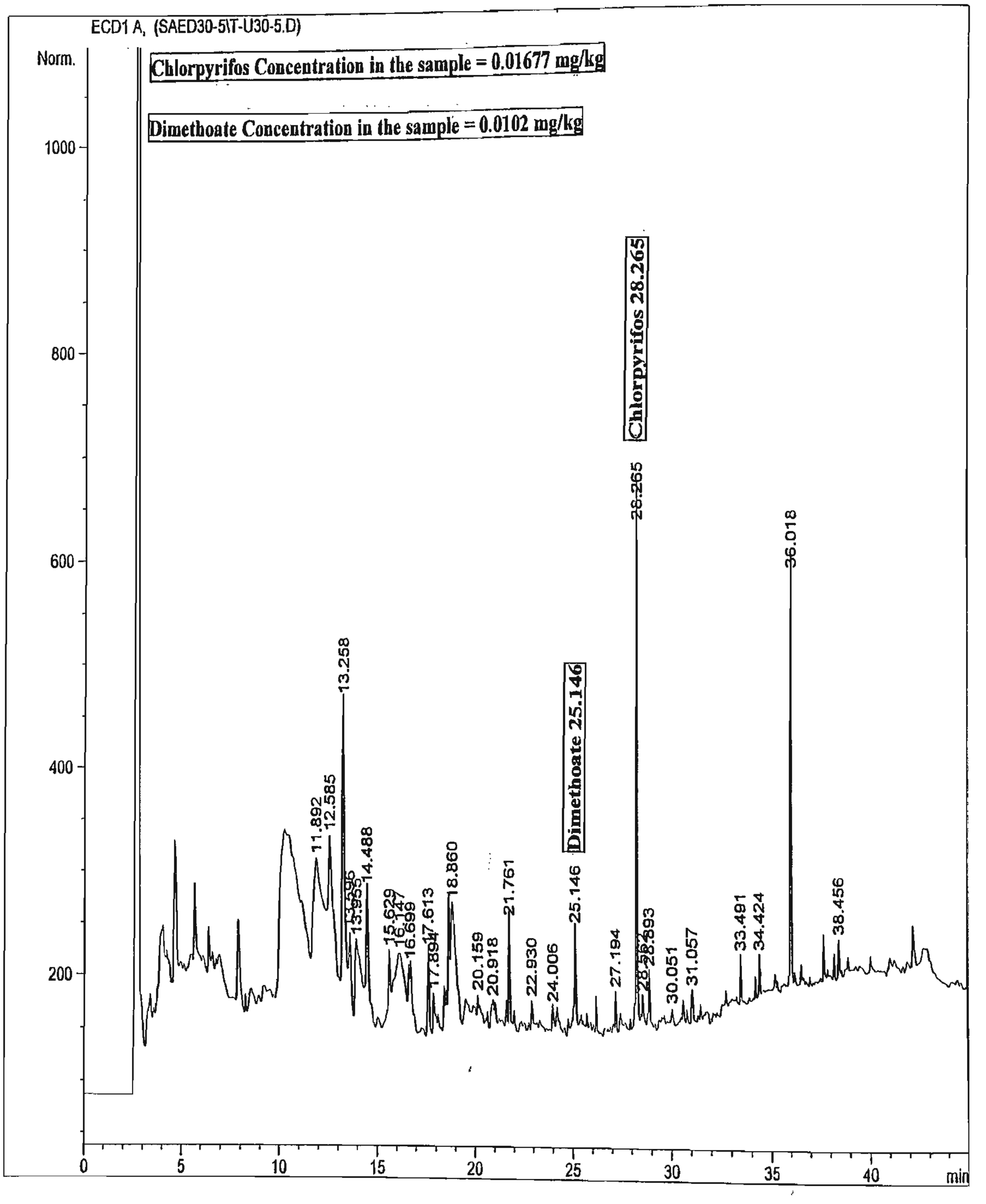
Figure (16) Chromatogram of Tomato sample as detected by NPD, in (UAE).

Sample Name: Tom-UAE-30-5

Data File C:\HPCHEM\1\DATA\SAED30-5\T-U30-5.D

```
Injection Date  : 5/30/00 8:18:39 PM           Seq. Line :  9
Sample Name     : Tom-UAE-30-5                      Vial :  9
Acq. Operator   : Saeed                              Inj :  1
                                              Inj Volume : 2 µl

Acq. Method     : C:\HPCHEM\1\METHODS\OC.M
Last changed    : 5/1/00 2:29:27 PM
Analysis Method : C:\HPCHEM\1\METHODS\OC.M
Last changed    : 5/31/00 11:42:54 AM by Saeed
                  (modified after loading)
```



Area Percent Report

```
Sorted By        :    Signal
Multiplier       :    1.0000
Dilution         :    1.0000
```

Figure (17): Chromatogram of Tomato sample as detected by ECD, in (UAE).

5.2 PESTICIDE RESIDUE SURVEY

5.2.1 RESIDUE SURVEY IN AUSTRALIA

The results shown in Tables 33, 34, 35 and 36 were from 9 tomato and 4 cucumber, samples collected from the Brisbane markets, which were processed and analyzed using GC-NPD and GC-ECD (2 columns). From the 39 analyses conducted on these samples, there was no one instance of pesticide residues detected in any of the cucumber samples. Chlorpyrifos was detected by ECD in one tomato sample from the Brisbane area (Table 33) at trace levels (0.0007mg/kg, 0.0008mg/kg).

On the other hand dimethoate was detected in five tomato samples from Brisbane and Bundaberg, all of which were below the MRL set for Australia.

Moreover, tomato samples from Bowen did not display detectable levels of any of the five pesticides considered in this study.

Table 33: Pesticide Residue analysis of Tomato & Cucumber samples collected in Australia (16/11/1999).

#	Crop type & Origin	GC Method	Pesticide Found	Pesticide concentration mg/kg	MRL (CODEX) mg/kg	MRL (AUS) mg/Kg
1	Tomato Brisbane	NPD	Dimethoate	0.013	1	1
		ECD Ch1	Chlorpyrifos	0.00068	0.5	0.5
			Dimethoate	0.01235	1	1
		ECD Ch2	Chlorpyrifos	0.00078	0.5	0.5
			Dimethoate	0.01174	1	1
2	Cucumber Brisbane	NPD	None	---	---	---
		ECD Ch1	None	---	---	---
		ECD Ch2	None	---	---	---

Table 34: Pesticide Residue analysis of Cucumber samples collected in Australia (24/11/1999).

#	Crop type & Origin	GC Method	Pesticide Found	Pesticide concentration mg/kg	MRL (CODEX) mg/kg	MRL (AUS) mg/Kg
1	Cucumber Brisbane	NPD	None	---	---	---
		ECD Ch1	None	---	---	---
		ECD Ch2	None	---	---	---

Table 35: Pesticide Residue analysis of Tomato and Cucumber samples collected in Australia (30/11/1999).

#	Crop type & Origin	GC Method	Pesticide Found	Pesticide concentration mg/kg	MRL (CODEX) mg/kg	MRL (AUS) mg/Kg
1	Tomato Brisbane1	NPD	Dimethoate	0.0128601	1	1
		ECD Ch1	Dimethoate	0.0106455	1	1
		ECD Ch2	Dimethoate	0.0162741	1	1
2	Tomato Brisbane 2	NPD	None	---	---	---
		ECD Ch1	None	---	---	---
		ECD Ch2	None	---	---	---
3	Tomato Brisbane 3	NPD	None	---	---	---
		ECD Ch1	None	---	---	---
		ECD Ch2	None	---	---	---
4	Cucumber Laidley 1	NPD	None	---	---	---
		ECD Ch1	None	---	---	---
		ECD Ch2	None	---	---	---
5	Cucumber Laidley 2	NPD	None	---	---	---
		ECD Ch1	None	---	---	---
		ECD Ch2	None	---	---	---

Table 36: Pesticide Residue analysis of Tomato samples collected in Australia (20/12/1999).

#	Crop type & Origin	GC Method	Pesticide Found	Pesticide concentration mg/kg	MRL (CODEX) mg/kg	MRL (AUS) mg/Kg
1	Tomato Brisbane	NPD	Dimethoate	0.0145	1	1
		ECD Ch1	Dimethoate	0.0087	1	1
		ECD Ch2	Dimethoate	0.0171	1	1
2	Tomato Bowen 1	NPD	None	---	---	---
		ECD Ch1	None	---	---	---
		ECD Ch2	None	---	---	---
3	Tomato Bowen 2	NPD	None	---	---	---
		ECD Ch1	None	---	---	---
		ECD Ch2	None	---	---	---
4	Tomato Bundaberg 1	NPD	Dimethoate	0.0725	1	1
		ECD Ch1	Dimethoate	0.0508	1	1
		ECD Ch2	Dimethoate	0.0737	1	1
5	Tomato Bundaberg 2	NPD	Dimethoate	0.0729	1	1
		ECD Ch1	Dimethoate	0.0523	1	1
		ECD Ch2	Dimethoate	0.0707	1	1

5.2.2 RESIDUE SURVEY IN THE UAE

The result of the analyses preformed on the Tomato and Cucumber samples collected during the market basket survey in the UAE are presented in Tables 37, 38, 39, 40, 41, 42, 43 and 44.

Table 37: Pesticide Residue analysis of Tomato and Cucumber samples collected in UAE (19/04/2000).

#	Crop type & Origin	GC Method	Pesticide Found	Pesticide concentration mg/kg	MRL (CODEX) mg/kg	MRL (AUS) mg/Kg
1	Cucumber 1 (UAE)	ECD	None	---	---	---
		NPD	Diazinon	0.0008	0.5	0.7
2	Cucumber 2(UAE)	ECD	None	---	---	---
		NPD	None	---	---	---
3	Cucumber 3(UAE)	ECD	None	---	---	---
		NPD	None	---	---	---
4	Tomato 1(UAE)	ECD	None	---	---	---
		NPD	Diazinon	0.0009	0.5	0.7

Of the four samples analyzed Table (37), one cucumber sample contained residues of diazinon 0.0008 mg/kg (detected by NPD), and one tomato sample contained residues of diazinon at 0.0009 mg/kg (detected by NPD).

Table 38: Pesticide Residue analysis of Tomato and Cucumber samples collected in UAE (29/04/2000).

#	Crop type & Origin	GC Method	Pesticide Found	Pesticide concentration mg/kg	MRL (CODEX) mg/kg	MRL (AUS) mg/Kg
1	Tomato 1(UAE)	ECD	None	---	---	---
		NPD	None	---	---	---
2	Tomato 2(UAE)	ECD	None	---	---	---
		NPD	None	---	---	---
3	Tomato 3(UAE)	ECD	None	---	---	---
		NPD	None	---	---	---
4	Tomato 4(UAE)	ECD	None	---	---	---
		NPD	None	---	---	---
5	Cucumber 1(UAE)	ECD	None	---	---	---
		NPD	None	---	---	---
6	Cucumber 2(UAE)	ECD	None	---	---	---
		NPD	None	---	---	---
7	Cucumber 3(UAE)	ECD	None	---	---	---
		NPD	None	---	---	---

In Table 38 none of the seven samples analyzed contained detectable amount of the five pesticides examined.

Table 39: Pesticide Residue analysis of Tomato and Cucumber samples collected in UAE (01/05/2000).

#	Crop type & Origin	GC Method	Pesticide Found	Pesticide concentration mg/kg	MRL (CODEX) mg/kg	MRL (AUS) mg/Kg
1	Tomato Jordan 1	ECD	Chlorpyrifos	0.00299	0.5	0.5
		NPD	Chlorpyrifos	0.00297	0.5	0.5
2	Tomato Jordan 2	ECD	None	---	---	---
		NPD	Chlorpyrifos	0.00235	0.5	0.5
3	Cucumber Liwa 1(UAE)	ECD	None	---	---	---
		NPD	None	---	---	---
4	Cucumber Liwa 1(UAE)	ECD	None	---	---	---
		NPD	None	---	---	---

In Table 39 two tomato samples from Jordan contained chlorpyrifos at detectable levels, which well below the MRL for this compound, while cucumber samples from Liwa (UAE) were free from detectable levels of residues.

Table 40: Pesticide Residue analysis of Tomato and Cucumber samples collected in UAE (06/05/2000).

#	Crop type & Origin	GC Method	Pesticide Found	Pesticide concentration mg/kg	MRL (CODEX) mg/kg	MRL (AUS) mg/Kg
1	Tomato Oman 1	ECD	Chlorpyrifos	0.00414	0.5	0.5
		NPD	Chlorpyrifos	0.002	0.5	0.5
2	Tomato Oman 2	ECD	Chlorpyrifos	0.00994	0.5	0.5
		NPD	Chlorpyrifos	0.00721	0.5	0.5
3	Tomato Jordan 1	ECD	None	---	---	---
		NPD	None	---	---	---
4	Tomato Jordan 2	ECD	None	---	---	---
		NPD	None	---	---	---
5	Cucumber Al-Ain 1(UAE)	ECD	Chlorpyrifos	0.00297	---	0.01
		NPD	Chlorpyrifos	0.00192	---	0.01
6	Cucumber Al-Ain 2 (UAE)	ECD	Chlorpyrifos	0.00555	---	0.01
		NPD	Chlorpyrifos	0.00385	---	0.01
7	Cucumber Liwa 1(UAE)	ECD	None	---	---	---
		NPD	None	---	---	---
8	Cucumber Liwa 2(UAE)	ECD	None	---	---	---
		NPD	None	---	---	---

From Table 40, Tomato samples from Oman and Cucumber samples from Al-Ain (UAE) contained trace level, of chlorpyrifos, which well below the MRL, while samples of Tomato from Jordan and Cucumber from Liwa (UAE) were free from detectable levels of pesticides.

Table 41: **Pesticide Residue analysis of Tomato and Cucumber samples collected in UAE (29/05/2000).**

#	Crop type & Origin	GC Method	Pesticide Found	Pesticide concentration mg/kg	MRL (CODEX) mg/kg	MRL (AUS) mg/Kg
1	Tomato Oman 1	ECD	Dimethoate	0.01131	1	1
		ECD	Chlorpyrifos	0.00381	0.5	0.5
		NPD	Chlorpyrifos	0.00189	0.5	0.5
2	Tomato Oman 2	ECD	None	---	---	---
		NPD	None	---	---	---
3	Tomato 1 (UAE)	ECD	Dimethoate	0.01025	1	1
		ECD	Chlorpyrifos	0.01677	0.5	0.5
		NPD	Chlorpyrifos	0.00933	0.5	0.5
4	Tomato 2 (UAE)	ECD	Dimethoate	0.02525	1	1
		ECD	Chlorpyrifos	0.01832	0.5	0.5
		NPD	Chlorpyrifos	0.02144	0.5	0.5
5	Cucumber Oman	ECD	Dimethoate	0.00743	---	2
		ECD	Chlorpyrifos	0.03126	---	0.01
		NPD	Chlorpyrifos	0.03349	---	0.01
6	Cucumber Oman Repeat	ECD	Dimethoate	0.0068	---	2
		ECD	Chlorpyrifos	0.04069	---	0.01
		NPD	Chlorpyrifos	0.04327	---	0.01
7	Cucumber Al-Ain 1 (UAE)	ECD	Dimethoate	0.00812	---	2
		ECD	Chlorpyrifos	0.00276	---	0.01
		NPD	None	---	---	---
8	Cucumber Al-Ain 2 (UAE)	ECD	Dimethoate	0.00891	---	2
		ECD	Chlorpyrifos	0.00344	---	0.01
		NPD	None	---	---	---
9	Cucumber Al-Ain 3 (UAE)	ECD	None	---	---	---
		NPD	None	---	---	---
10	Cucumber Al-Ain 4 (UAE)	ECD	None	---	---	---
		NPD	None	---	---	---

As shown in Table 41, four tomato samples were analyzed, two from Oman and two from the UAE. Dimethoate and Chlorpyrifos were detected in trace amounts in both samples from the UAE and one from Oman, the second sample from Oman was free from detectable levels of the pesticides examined.

In the case of cucumber, 5 samples were analyzed 4 from the UAE, and one from Oman, however the detection of Chlorpyrifos at levels above the MRL necessitated a repeat sample preparation and analysis of the original box of cucumbers to confirm this finding.

The cucumber samples from Al-Ain (UAE) had either trace amounts of Chlorpyrifos and Dimethoate or no detectable traces of the pesticides investigated.

Table 42: Pesticide Residue analysis of Tomato and Cucumber samples collected in UAE (20/06/2000).

#	Crop type & Origin	GC Method	Pesticide Found	Pesticide concentration mg/kg	MRL (CODEX) mg/kg	MRL (AUS) mg/Kg
1	Tomato UAE 1	ECD	Dimethoate	0.0054	1.0	1.0
		ECD	Chlorpyrifos	0.0113	0.5	0.5
		NPD	Chlorpyrifos	0.0076	0.5	0.5
2	Tomato UAE 2	ECD	Dimethoate	0.0074	1.0	1.0
		ECD	Chlorpyrifos	0.014	0.5	0.5
		NPD	Chlorpyrifos	0.0131	0.5	0.5
3	Tomato UAE 3	ECD	Dimethoate	0.0085	1.0	1.0
		ECD	Chlorpyrifos	0.0013	0.5	0.5
		NPD	Chlorpyrifos	0.0009	0.5	0.5
4	Tomato UAE 4	ECD	Dimethoate	0.0114	1.0	1.0
		ECD	Chlorpyrifos	0.0092	0.5	0.5
		NPD	Chlorpyrifos	0.0016	0.5	0.5
5	Tomato UAE 5	ECD	Dimethoate	0.0089	1.0	1.0
		ECD	Chlorpyrifos	0.0046	0.5	0.5
		NPD	None	---	---	---
6	Tomato UAE 6	ECD	Dimethoate	0.014	1.0	1.0
		ECD	Chlorpyrifos	0.0088	0.5	0.5
		NPD	Chlorpyrifos	0.0013	0.5	0.5
7	Tomato Oman 1	ECD	Dimethoate	0.01	1.0	1.0
		ECD	Chlorpyrifos	0.0047	0.5	0.5
		NPD	Chlorpyrifos	0.0017	0.5	0.5
8	Tomato Oman 1	ECD	Dimethoate	0.001	1.0	1.0
		NPD	None	---	---	---
9	Cucumber Al Ain (UAE) 1	ECD	Dimethoate	0.0019	---	2.0
		NPD	None	---	---	---
10	Cucumber Al Ain (UAE) 2	ECD	Dimethoate	0.0057	---	2.0
		NPD	None	---	---	---
11	Cucumber Oman 1	ECD	Dimethoate	0.0073	---	2.0
		ECD	Chlorpyrifos	0.0056	---	0.01
		NPD	Chlorpyrifos	0.0017	---	0.01
12	Cucumber Oman 2	ECD	Dimethoate	0.0094	---	2.0
		ECD	Chlorpyrifos	0.0057	---	0.01
		NPD	Chlorpyrifos	0.0022	---	0.01
13	Cucumber Oman 3	ECD	Dimethoate	0.0075	---	2.0
		ECD	Chlorpyrifos	0.0093	---	0.01
		NPD	Chlorpyrifos	0.0024	---	0.01
14	Cucumber Oman 4	ECD	Dimethoate	0.0061	---	2.0
		ECD	Chlorpyrifos	0.005	---	0.01
		NPD	None	---	---	---
15	Cucumber Oman 5	ECD	Dimethoate	0.0069	---	2.0
		ECD	Chlorpyrifos	0.0058	---	0.01
		NPD	Chlorpyrifos	0.0017	---	0.01

From Table 42, we can see that 15 samples were analyzed, 6 tomato from the UAE, 2 tomato from Oman, 2 cucumber from the UAE, 4 cucumber from Oman.

In all cases, both Dimethoate and Chlorpyrifos were detected in traces amount (below the MRLs for each compound).

Table 43: Pesticide Residue analysis of Tomato and Cucumber samples collected in UAE (11/07/2000).

#	Crop type & Origin	GC Method	Pesticide Found	Pesticide concentration mg/kg	MRL (CODEX) mg/kg	MRL (AUS) mg/Kg
1	Cucumber (UAE) 1	ECD	Dimethoate	0.01982	---	2
		ECD	Chlorpyrifos	0.0066	0.5	0.5
		NPD	None	---	---	---
2	Cucumber (UAE) 2	ECD	Dimethoate	0.0155	---	2
		NPD	None	---	---	---
3	Tomato Jordan 1	ECD	Dimethoate	0.06111	1	1
		ECD	Chlorpyrifos	0.0071	0.5	0.5
		NPD	Chlorpyrifos	0.0019	0.5	0.5
4	Tomato Jordan 2	ECD	Dimethoate	0.04388	1	1
		ECD	Chlorpyrifos	0.01086	0.5	0.5
		NPD	Chlorpyrifos	0.00163	0.5	0.5
5	Tomato (UAE) 1	ECD	Dimethoate	0.04419	1	1
		NPD	None	---	---	---
6	Tomato (UAE) 2	ECD	Dimethoate	0.02032	1	1
		NPD	None	---	---	---
7	Tomato (UAE) 3	ECD	Dimethoate	0.03256	1	1
		NPD	None	---	---	---

From Table 43, it can be seen that Dimethoate was detected in all samples of Cucumber and Tomatoes at trace levels below the MRL, while Chlorpyrifos was less frequently detected in Jordanian Tomatoes and in one Cucumber sample from the UAE.

Table 44: Pesticide Residue analysis of Tomato and Cucumber samples collected in UAE (01/10/2000).

#	Crop type & Origin	GC Method	Pesticide Found	Pesticide concentration mg/kg	MRL (CODEX) mg/kg	MRL (AUS) mg/Kg
1	Tomato Jordan 1	ECD	Chlorpyrifos	0.00423	0.5	0.5
		NPD	None	---	---	---
2	Tomato Jordan 2	ECD	Chlorpyrifos	0.00263	0.5	0.5
		NPD	Chlorpyrifos	0.01757	0.5	0.5
3	Tomato (UAE) 1	ECD	Chlorpyrifos	0.00196	0.5	0.5
		NPD	Chlorpyrifos	0.01526	0.5	0.5
4	Tomato (UAE) 2	ECD	Chlorpyrifos	0.00107	0.5	0.5
		NPD	None	---	---	---
5	Cucumber Oman 1	ECD	None	---	---	---
		NPD	None	---	---	---
6	Cucumber Oman 2	ECD	None	---	---	---
		NPD	None	---	---	---
7	Cucumber (UAE) 1	ECD	Chlorothalonil	0.00304	5.0	5.0
		NPD	None	---	---	---
8	Cucumber (UAE) 1 Repeat	ECD	None	---	---	---
		NPD	None	---	---	---
9	Cucumber (UAE) 2	ECD	Chlorothalonil	0.00449	5.0	5.0
		ECD	Chlorpyrifos	0.00436	---	0.01
		NPD	Chlorpyrifos	0.00578	---	0.01
10	Cucumber (UAE) 2 Repeat	ECD	Chlorothalonil	0.00409	5.0	5.0
		ECD	Chlorpyrifos	0.00534	---	0.01
		NPD	Chlorpyrifos	0.00682	---	0.01

From Table 44, both tomato samples from Jordan and those from the UAE contained trace amount of Chlorpyrifos.

Both cucumber samples from Oman were free from detectable levels of the pesticides examined.

The cucumber samples from the UAE both showed traces of Chlorothalonil necessitating a repeat processing and analysis of the original produce sample. Chlorpyrifos was also found in trace levels in one of the two samples.

6.0 DISCUSSION

6.1 RECOVERY TEST RESULTS

From the obtained recovery results (spike tests) (as shown in Tables 29, 30, 31 and 32) we can say that those results generally in agreement with those found in previous studies as follows.

The study done by Nakamura *et al.,* (1994) reported that the recovery percentage of Diazinon, Chlorpyrifos and Dimethoate in Cucumbers samples were 79.7 ± 3.6, 76.6 ± 5.9 and 85.1± 7.9 respectively.

Moreover, Miyahara *et at.* (1994) in Japan, reported that the recovery percentage of Chlorpyrifos in Cucumber samples was 75%. While the recovery percentage of chlorpyrifos in other crops includes grapefruit, lemon, red salad, mushroom, cherry, asparagus, wheat and soybean ranged between 63-138%.

Lehotay and Valverde-Garcia (1997) reported in there study that, the recovery percentage of Dimethoate when using acetone as solvent ranged from 73% to 95%, while the recovery percentage of Diazinon ranged from 79% to 85%, moreover, the recovery percentage of Chlorpyrifos ranged from 70% to 97% and the recovery percentage of Chlorothalonil ranged from 33% to 87%.

Moreover, Gelsmino *et al.,* (1997) reported that the recovery percentage for Chlorothalonil, Chlorpyrifos, Diazinon and Dimethoate in tomato samples were 77.8, 87.7, 88.4 and 94.2 respectively and the recovery percentage for the same pesticides in carrot samples were 79.3, 87.8, 83.4 and 92.8 for Chlorothalonil, Chlorpyrifos, Diazinon and Dimethoate respectively. In same study they found that the recovery percentage for Chlorothalonil, Chlorpyrifos, Diazinon and Dimethoate were 83.5, 88.2, 90.1 and 93.5, respectively in Melon samples.

Cheng and Dennison (1999) found that the recovery percentages of Chlorpyrifos, Diazinon, Dimethoate and Chlorothalonil were 93 %, 92 %, 100 % and 103 %, respectively.

In another study done by Al-Saleh *et al.,* (1999) in Saudi Arabia in grain samples locally grown showed that the recovery percentage of Dimethoate ranged from 72 to 90%.

According Mishra *et al.* (2001) in a study done in India, the authors claimed that the recovery percentage of dimethoate was 90.8 %-91.8 % in some vegetables.

However, as reported by the Guidelines for residues monitoring in the European Commission (1997) that recovery percentages are accepted within the range of 60 % and 140 % according to the method used and the variability of the physical properties of each compound.

6.2 RESIDUE SURVEY

In the evaluation of the results obtained, three basic principles were taken in to consideration:

Firstly, residues of any of the pesticides tested had to be confirmed by two detectors (ECD and NPD), otherwise if it is detected by one detector only, this result should be rejected.

Secondly, if the determined residue exceeds the MRL either as reported by (Codex Alimentarius, 2000) or Australian Food Standards Code (Commonwealth of Australia, 1997) as its shown in table (45), this sample should be committed to reanalysis.

Thirdly, in the case of chlorothalonil, this compound can only detected by ECD, or in the case of Metalaxyl, can only be detected by NPD, therefore, any samples containing chlorothalonil or Metalaxyl residues should be reanalyzed for confirmation.

6.2.1 RESIDUE SURVEY IN AUSTRALIA

The total number of collected and analyzed samples were 4 and 9 for cucumber and tomato, respectively. The results in Tables 33, 34, 35 and 36 revealed that cucumber samples, generally contained some evidence of pesticide residues, but as they were not confirmed by two detectors, therefore, they must considered free of residues.

On the other hand, the tomato samples analyzed contained residues of dimethoate in five instances, which were confirmed by the two detectors, as follows; 0.012, 0.013, 0.013, 0.065 and 0.065 mg/kg. This finding indicates that all residues were well below the MRL for dimethoate (1.0 mg/kg) as reported by Codex and Australian Food Standards Code as shown in Table 32. Moreover, the percentage of samples containing detectable residues was 55.55 %.

Table 45: Maximum residue limits of the tested pesticides as reported by Codex Alimentarius (2000) & Commonwealth of Australia, (1997) (as mg/kg)

	TOMATO		CUCUMBER	
Compound	**Codex**	**Australia**	**Codex**	**Australia**
Dimethoate	1.0	1.0	---	2.0
Diazinon	0.5	0.7	0.1	0.7
Chlorpyrifos	0.5	0.5	---	0.01
Chlorothalonil	5.0	5.0	5.0	5.0
Metalaxyl	0.5	0.2	0.5	0.2

6.2.2 RESIDUE SURVEY IN THE UAE

In general, as shown in Table (46), from 32 tomato samples collected 18 were locally produced (56.25 %), while 14 samples (43.75 %) were imported. In the case of cucumber, the proportions were 73.3 % (22 samples) and 26.7 % (8 samples) for local and imported samples, respectively.

Table 46: Origin of produce samples collected in the UAE.

CROP	LOCAL	IMPORTED	TOTAL
TOMATO	18(56.25%)	14(43.75%)	32(100%)
CUCUMBER	22(73.3%)	8(26.7%)	30(100%)
TOTAL	40(64.5%)	22(35.5%)	62(100%)

In addition, as indicated in Table 47, the proportion of contaminated tomato samples were higher among imported samples (57 %) than for local samples (44 %). In comparison the percentages for cucumber were 13.6 % and 62.5 % for local and imported samples, respectively.

Table 47: Proportion of samples on the UAE market containing detectable pesticide residues.

CROP	LOCAL	IMPORTED	TOTAL
TOMATO	8(44.4%)	8(57%)	16(50%)
CUCUMBER	3(13.6%)	5(62.5%)	8(26.6%)
TOTAL	11(27.5%)	13(59%)	24(38.7%)

The results indicated that, 8 cucumber samples were contaminated (26.6 % of all samples), while for tomato there were 16 contaminated samples (50 % of all samples). In addition, the most predominant pesticide residue was chlorpyrifos, as it was detected in all of the sixteen tomato samples and in all of the eight cucumber samples. Chlorothalonil was found in only one cucumber sample at 0.004 mg / kg (3.33 % of all samples).

Moreover, other pesticides such as dimethoate and diazinon were detected by one detector only (either NPD or ECD), but these instances were discounted as they were not confirmed by a secondary detection. In addition, metalaxyl residues were not detected in any samples under survey.

In comparing the measured residue levels of confirmed pesticide detections with the MRL's reported by the Codex and Australian Food Standards Code, it can be seen that these were well below these maximum levels. Only one cucumber sample (from Oman) contained residues of chlorpyrifos (0.03 mg/ kg), which were higher than the MRL (0.01 Mg / kg) representing 3.3% of the samples collected.

By comparing the results from either the Australian, or the UAE surveys with those of previously studies, it can be said that, residue levels are generally in agreement with those found in different surveys as follows:

Walter *et al.,* (1999) reported that about 3325 samples were tested by the Connecticut Agricultural Experiment station for pesticides residues. They found that 2150 (64.71%) samples were free from residues, while 1136 (34.1%) samples contained residues, 6 samples (0.2 %) contained residues, which were over the U.S. Environmental Protection Agency (EPA) tolerances and 33 samples (1.0 %) contained residues, for which there was no EPA tolerance.

The Michigan food monitoring program (1992) reported that 23 cucumber samples contain pesticides from the 42 samples screened. Three pesticides were detected, Carbofuran was detected in 14% of the samples at the range of (0.007-0.18 ppm), while Chlorothalonil was detected in 24% of the samples at the range of (0.08-0.40 ppm) which is below the Australian MRL (5.0 ppm). Also chlorothalonil was detected in 5% of the samples in the next study (1996) by the same organization at the range of 1.5 ppm, which is below the Codex and the Australian MRL (5.0 ppm).

The 19th and the 18th Australian total diet survey (2001), found that pesticide maximum contaminant levels (mg/kg) in fruits and vegetables sorted by Chlorothalonil, Chlorpyrifos, Dimethoate and Diazinon, were below the Australian Maximum Residue Levels (MRL), except that for Chlorpyrifos which was found above the Australian (MRL) in grapes at 0.1 mg/kg and at 0.03 mg/kg (Australian MRL = 0.01mg/kg). In addition, Chlorpyrifos was found in lettuce at 0.020 mg/kg (Australian MRL 0.01 mg/kg). This compound was also detected in eggplant equal to the level of the Australian MRL, as mentioned above.

Moreover, the Netherlands Quality Program for Agricultural products (1999) revealed that, from analyzing 280 tomato samples, 85.3 % were free from residues, 14.3 % contained residues lower than the maximum limits, and only 0.4 % were higher than maximum residue limits. While, in the case of cucumber samples, from the 210 analyzed samples, 83.3% were found with no residues and 14.3 % with lower than the maximum limits and 2.4 % with residues higher than the maximum limits.

Furthermore, the US pesticides data program (2001), found chlorothalonil in 33 cucumber samples (4.5 %) in the range of 0.007 – 0.091 mg/kg. While for tomato, 23 samples (8.7 %) contained chlorothalonil in the range of 0.008 – 0.14 mg/kg. In the case of chlorpyrifos, 9 cucumber samples (1.2 %) were contaminated in the range of 0.007 – 0.094 mg/kg, whereas 55 tomato samples were contaminated with chlorpyrifos in the range of 0.005 – 0.094 mg/kg. Diazinon was detected in three cucumber samples (0.4 %) and in 2 tomato samples (0.5 %) in the range of 0.005 – 0.024mg/kg and 0.003 mg/kg, respectively. Dimethoate was detected in 5 cucumber samples (0.7 %) at 0.003 – 0.092 mg/kg and in 5 tomato samples (1.4 %) at 0.003 – 0.042 mg/kg. Lastly, metalaxyl was not detected in this survey either in cucumber or tomato samples.

According the United States Department of Agriculture (USDA 1996, 1997, 1998 & 2001), for the calendar years 1996-1999, 1819 tomato samples from the USA were screened for Chlorothalonil, which was detected in 160 samples (8.8%) within the range of (0.005 - 2.4 ppm) which is below the Codex MRL (5 ppm).

The same study showed that of the 1318 samples of tomatoes screened for Chlorpyrifos in the same period, only 135 (10.2%) displayed detectable levels of this compound within the range of 0.005-0.57 ppm. This indicates that some samples had exceeded the Codex MRL 0.5 ppm.

The same samples (1318) were screened for Diazinon during the same period, of which, only 12 samples (0.9%) were contaminated within the range of 0.003-0.090 ppm, which is well below the Codex MRL of 0.5 ppm.

In addition, 1960 samples were screened for Dimethoate. Only 4 samples (0.2%) displayed detectable levels of this compound within the range of 0.1-0.4 ppm, which is below the Codex MRL of 1 ppm.

Furthermore, 451 tomato samples were screened for Metalaxyl, with only 2 samples (0.4%) displaying detectable levels within the range of (0.005-0.026 ppm) which is below the Codex MRL 0.5 ppm.

From the same study (USDA, 2001) between 729 and 730 cucumber samples were tested for Chlorothalonil, Chlorpyrifos, Diazinon and Dimethoate with 180 samples tested for Metalaxyl.

Only in the case of Dimethoate did any of the detections approach or exceed (though only slightly) the CODEX MRL, for the remaining compounds, all detections were below the CODEX MRL.

In the study done by Aysal *et al.*, (1999) in on tomatoes in Turkey, the authors showed that the amount of chlorpyrifos theoretically applied per plant during growing season was 15552 µg. The amount of chlorpyrifos residue at the final harvesting time was found to be 11594 µg/plant. That amount corresponds to 74.5% of the theoretically applied dose. Tomato fruits were found to contain 1.1% of the total chlorpyrifos residue of the whole plant. The total chlorpyrifos residues in tomatoes harvested at early, mid in tomatoes were below the international MRL (Codex Alimentarius, 2000)

As shown in table (48) domestic tomatoes from Al Ain, 94% of the samples were found to contain residues of at least one pesticide. Organophosphate and organochlorine compounds were detected in the samples. Which were collected directly from the field (unwashed). The most frequently detected pesticide residue was Lindane followed by ethyl parathion and then DDT. Other pesticides residues detected were BHC and its four isomers, heptachlor, chlorpyrifos, dimethoate, kelthane and endosoulfan. Dimethoate and kelthane were detected only in one sample. The same pesticides with the exception of dimethoate, heptachlor, and two isomers of

BHC were also found in Liwa on tomato and onion. Aldrin was not detected in Al Ain, samples although it found only in one sample from Liwa. (ERADA, 1997)

Table 48: Concentrations of Chlorinated and Organophosphate Pesticides Detected in Biota Samples from the Al Ain District (data in ng/gram dry weight). (After ERADA, 1997).

a-BHC	b-HBC	g-BHC	d-BHC	Heptachlor	Heptachlor Epox.	Endosulfan I	Endosulfan II	Endosulfan Sulfate	4,4 DDT	Kelthane	Dimethoate	Chlorpyrifos/ Ethyl Parathion
0.59	27.4	0.31	25.2	0.78	0.18	2.23	0.25	0.44	11	151	91.4	219
0.42		0.47		25.2	0.17	2.07	0.46		35			79
2.36		0.71		0.84	.46		2.13		6.3			8
6.97		0.5		0.47	.25		0.54		8.2			2250
122		1.29							4.3			36
0.66		0.58							7.9			245
		0.74										78.9
		3.11										8.22
		0.50										
		1.29										
		0.58										
		0.74										
		0.47										
		.0.31										
		0.71										
		0.78										
		1.5										

Surveys of both domestically grown and imported conventionally produced foods have been conducted by the National Food Processors Association (NFPA), the California Department of Food and Agriculture (CDFA) and the FDA in 1989. These surveys have shown that 93, 79 and 60%, respectively, of conventionally grown foods contain no detectable pesticide residues. Of the food that did contain detectable residues, virtually all contained residue concentrations below the maximum residues limit (MRL), (Brewer, 2002). A breakdown of the CDFA surveillance program in 1989 showed that in 14,987 samples:

1. No residue detected in 77.94% of samples.
2. Residue within tolerance detected in 21.34% of samples.
3. The number of samples within tolerance was 98.28%.
4. Residue over tolerance was detected in 0.22% of samples.
5. Illegal residue (not approved for that crop) was detected in 0.71% of samples.
6. Residue with no tolerance established was found in 0.49% of samples.

(Brewer, 2002).

In north coast of Central Java, especially around Brebes, the most commonly used insecticides were the organophosphates protiofos, metamidofos, profenofos, chlorpyrifos, and diazinon. Profenofos residues on produce from the Brebes area were in the range 0.194- 0.481 ppm, and chlorpyrifos residues were up to 0.612 ppm (Soeriaatmadja *et al.* 1993).

In Yogyakarta the highest residues detected were of chlorpyrifos (1.4 ppm) in hot peppers, and prophenofos (1.7 ppm) in shallots. Residues of BHC found in cucumber and shallots were in the range 0.007- 0.017 ppm, whereas the maximum residues limit (MRL) is 0.001 ppm. Lindane was detected in hot pepper at 0.007 ppm (Soeriaatmadja *et al.* 1993).

In the Sukabmi area of West Java, pesticide spraying of vegetable crops was intensive. Eggplant samples contained residues of diazinon of 0.285 ppm, and 0.03 ppm of carbaryl. Around Serang, decamethrin residues of 0.106 ppm and diazinon residues of 0.202 ppm were found on yardlongbeans. Diazinon was also found in hot peppers, in the range 0.015- 0.03 ppm. At the eastern part of West Java, BHC residues in cucumber and hot peppers were in the range 0.017- 0.037 ppm (Dibiyantoro *et al.* 1989).

Comparing obtained results with those reported in previous studies either in The UAE or in different places confirmed that in general they are in the same residue levels. Moreover, the required standards of The UAE is adopting Codex standards for MRL`s of pesticides in foodstuffs.

The Codex Alimentarius system is an international Maximum Residue Limits (MRL) standard, which was developed taking into consideration the average daily intake of different commodities. However this standard may not be appropriate in the UAE, where consumers have different diet requirements than those on which the Codex standards were developed. Also the question can be asked "was the Codex system developed around adult or infant consumers?" Infant consumers are at greater risk than adult consumers from pesticides. For example in this study we found that the tomato consumption among UAE consumers was double that of the consumption of tomatoes per person per week in Australia. In order to determine the Maximum Residues Limit (MRL) the daily food intake of the general population must be known.

As there are cultural differences in food intake between populations, an international standard is not always appropriate. Therefore it is suggest that a baseline survey be made among UAE consumers to identify consumer food preferences and consumption patterns for different food commodities. The results of this survey will define the acceptable daily intake (ADI), which is the amount of a food additive that can be eaten every day for an entire lifetime without adverse effect, Commonwealth of Australia (1999). This will also allow the development of a UAE standard for pesticides residues in food (MRL), which could be expanded to other Gulf Cooperation Council (GCC) countries were food preferences and consumption patterns are probably similar to that of the UAE.

Determining if the levels of pesticides residues observed during this study are safe for humans.

The fact that consumption of tomatoes in the UAE is twice that of in Australia, and assuming all other factors to be equal (i.e. Application of pesticides and climatic factors) we still found that the percentage of pesticide residue in tomatoes in the UAE was under the maximum residue limit (MRL) of Codex and the Australian standards.

The Australian results from this study were expected; because of the good agriculture-monitoring program that exists in that country, which leads to good agricultural practices.

But at the same time the UAE results from this study were surprising, because the agricultural methods employed by UAE farm workers (during the period of this study) are considered to be in-consistent, and cases of over application were often observed in the field. These inconsistent and irregular practices included the following:

1. The right type of pesticide, time of application, correct dose, and safety period were not taken into consideration by most of the farmers observed in the progress of this study.

2. Most of the farm workers do not understand some of the more complex principals of agriculture, especially the right methods of using pesticides and chemical fertilizers, and often apply pesticides on vegetables a few hours before or after harvesting, in preparation for shipment to the market.

3. Most farm workers do not understand pesticide application procedures and cannot read the user directions on the labels of the pesticide containers.

For these reasons the expectations of this study was to find significant residues in tomato and cucumbers for those pesticides targeted in this study. However, the results largely indicated levels of pesticide residues within the acceptable standards.

The low pesticide residues found in this study were probably due to the following:

1. High air temperatures and high levels of sunshine in the UAE during most of the year rapidly assist in the breakdown of pesticides.

2. Farm workers not following agriculture procedures approved by the agricultural authorities, which specify particular pesticides for different crops.

The pesticides targeted in this study were pesticides, which are recommended by the agriculture authorities for tomatoes and cucumbers. Therefore the application of incorrect (non-targeted) pesticides by farm workers may have biased the results of this study.

3. The dilution, and or substitution of some pesticide products imported into the UAE by unscrupulous individuals, operating outside the law may be another factor for the low pesticide residues observed in the crops investigated. Perhaps in some cases, the pesticide being applied was at a lower concentration, or was a different product to that specified on the label.

During the study it was found that consumer confidence in the UAE for locally produced fruit & vegetable products was low, for example 65% of consumers were concerned about high levels of pesticides in local vegetables. Hence a new system of pesticide regulation and management needs to be developed, applied and promoted in order to guarantee food quality and to develop higher consumer confidence.

Because the UAE operates an open international market, an increasing variety of food materials, including fruit and vegetables are imported each year. As the quantities and variety of this material increases, so too should the capability of the agricultural authorities to check and control the import of harmful pesticides and contaminated foods. State of the art facilities currently exist in the UAE and the agricultural authorities need to utilize these facilities to assist with the control and enforcement of UAE standards.

The agricultural authorities need to be vigilant not only at major ports, but also at the borders of neighbouring countries such as the Sultanate of Oman, where there are presently areas of open borders (e.g. Al Ain / Buraimi) across which produce is transported daily.

The origins of the imported food items (and the pesticide practices) need to be considered when approving import permits in order to protect UAE consumers. The standards adopted in the originating countries should be in line with UAE accepted standards (ie. Codex), because many foreign countries use pesticides which are harmful to human health and which are banned in the UAE and many other countries throughout the world.

It is therefore necessary to have an inspection procedure, to examine produce prior to entering the UAE. Furthermore regular "basket" surveys are required to check products (both local & foreign) in the market place to determine pesticide levels, and these results should be published regularly (perhaps annually) for consumers. This will require a labeling method to identify each batch of produce and its origin, and should dramatically improve consumer confidence.

The UAE farmers need to be involved in "clean food" programs, which could be encouraged by higher market prices (this study showed that 56% of consumers are willing to pay higher prices for produce free of pesticides). This would contribute to the UAE economy, as both local and international consumer confidence would grow leading to greater demand for produce locally and a demand for produce for export.

However, the main benefit from introducing stricter controls and new agricultural methods would be a general improvement in the health of UAE consumers, and a reduced incidence of illnesses caused by pesticide accumulation and exposure to chemical fertilizers.

An overall improvement in the health of the UAE population may also produce additional benefits such as the reduction in the levels of medical treatment with an overall saving on the annual health budget. Other benefits may include a generally cleaner environment, and an agricultural sector that would be more attractive to foreign investment.

In conclusion, the development of an effective regulating system will lead to a healthier population, and a cleaner environment that will provide sustainable economic development in the UAE.

It is recommended that the following initiatives be considered when developing an agricultural monitoring system:

1. Human health should be the first priority in determining policies for agricultural practices.

2. Protection of the environment may be assisted by regulating the import, sale and use of pesticides and chemical fertilizers.

3. The sale of pesticides and chemical fertilizer products should be by prescription issued under the control of the agricultural authorities, or by a licensed qualified technical officer who has received training in the prescription of, and the application of these products.

4. All authorized agricultural companies should be obliged, before re-licensing, to employ an agricultural technical officer to provide advice regarding efficient and appropriate agricultural products and practices to customers.

5. Farm managers should keep records for all crops sent to the market, so that the authorities can monitor the origin and application of pesticides and chemical fertilizers.

6. Encourage farmers to produce food products free of pesticides and chemical fertilizers by providing government incentives.

7. Involve the media to promote awareness regarding "clean agricultural practices" amongst farmers and consumers.

8. Utilize existing food control centers in the UAE to sample locally grown and imported produce.

9. Prosecute farmers, agricultural agents and importers who break the law relating to food product standards in the UAE.

10. Import original (not formulated) pesticides with accompanying certifications.

11. All imported pesticide products and all produce should be subject to sampling and subsequent analysis, to enforce UAE standards.

7.0 CONCLUSIONS AND RECOMMENDATIONS

This study was conducted firstly to evaluate the level of concern and understanding in the public of the UAE over the issue of pesticide residues in foodstuffs.

Secondly, residue testing was performed on two crops both in Australia and the UAE to determine the actual level of residues for the selected pesticides and to determine whether or not they fell within acceptable limits.

7.1 CONCLUSIONS

7.1.1 CONSUMER FOOD SAFETY SURVEY RESULTS

The information obtained in this study indicated that females were less concerned about pesticide residues than were males. It seems that irrespective of gender the differences in awareness was directly related to the level of education (being greatest in university educated people). The percentage of the sample as whole that showed concern about pesticide residues in food commodities was reasonable. This is in agreement with the result found by the national survey conducted by the food marketing institute in USA, where approximately 75 percent of the consumers polled said that they were very concerned about pesticides in their food, a percentage that is higher than that of consumers concerned about cholesterol, fats, salt, additives, or any other food component. (Tweedy *et al.,* 1991).

Fresh fruits and vegetables ranked first relative to other selected food commodities as far as the level of concern about pesticide residues, (69%) was with concerned, while baby food came second (31%).

Concern about the place of origin of fresh fruits and vegetables, was greater in males in both categories. (UAE nationals and other nationalities)

Comparison of the levels of consumption of tomatoes and cucumbers showed that more tomatoes were consumed than cucumber, (the rate of consumption was 64% of the population consume one kilogram per person per week while for cucumber

43% of the population consume 1 kilogram per person per week). This result can be attributed to the food consumption habits of the population.

The proportion of the public using methods to reduce the effects of pesticide residues on food commodities were 94% and 91% of males and females respectively. This indicated that the level of awareness within the population to pesticide residues is substantially high and that the majority of the sample used both washing and peeling measures to reduce pesticide residues.

The willingness to reduce pesticide intake was indicated the proportions of those surveyed (88% and 44% of males and females respectively) who indicated their readiness to pay higher prices for pesticide- free commodities.

Sixty eight percent of the sample indicated that their primary source of information was from other people while reliance on the media for information on this issue was substantially low.

Knowledge about possible effects of pesticide residues among the sample categories was low. This result indicated that the role-played by media in this respect needs to be revised and possibly strengthened.

It can be said that, the result of this survey in generally are in agreement with the results, reported in January 1998 by Pest Control Technology issue (Georgia Pest Management Newsletter, 1998):

1. 77% of consumers are concerned about pesticide exposure at home or work.
2. 66% of consumers believe that pesticides cause cancer.
3. 85% of consumers would pay more for pest control with fewer pesticides. 75% said that they would pay 10%-25% more.
4. 85% of consumers would like to have odorless pesticides.

7.1.2 RESIDUE TESTING RESULTS

The results from both market place produce surveys revealed that:

All pesticide residues detected in this survey were below the maximum residue limits reported either by the Codex Alimentarius or Australian Food Standards Code, except for one sample of cucumber from Oman, which contained chlorpyrifos residues higher than that stated by the Australian standard.

Chlorpyrifos residues dominated the list of compounds as it was detected in 8 cucumber and 16 tomato samples from a total of 24 from the 62 analyzed samples (38.7 %) from the UAE.

Dimethoate was detected only in Australian tomato samples representing 38.4% of the total Australian samples.

Chlorothalonil was found in only one sample.

Neither Diazinon nor Metalaxyl were detected during this survey.

Therefore, it can be said that, consumption of the vegetables targeted in this study should not cause any harm to humans. These finding are in agreement with the investigation of the association of pesticide exposure and cancer, in the 1994 report by The National Cancer Institute of Canada and the Canadian Cancer Society (Georgia Pest Management Newsletter, 1998), which concluded that:

1. Pesticides are important for crop production and food quality. Pesticide use is associated with a decline in the costs of fruits and vegetables.
2. A diet rich in fruits and vegetables is important to reduce cancer risk.
3. An increased intake of pesticide residues associated with eating more fruits and vegetables does not increase the risk of cancer. Even if it did, it would be outweighed by the benefits of the diet.

4. Only about 2% of all cancer deaths can be linked to all forms of environmental pollution. This statement means that only 2 out of a 100 cancer deaths are linked to any environmental threat, including air pollution, water pollution, pesticides, etc.

5. Exposure to pesticide residues in food is minimal and is below those levels deemed safe by regulatory agencies

7.2 RECOMMENDATIONS

This study is considered to be the first official thesis, conducted to evaluate pesticide residues and their related problems in the UAE. Therefore, after investigating the results and the public concern about this problem, the following recommendations can be made.

In order to raise the public interest, concise, simple but scientifically based print articles, TV or radio programs should be produced to illustrate both the benefits and hazards of using pesticides in plant protection programs. These balanced articles should promote the concept of how the users of pesticides may take care to prevent environmental pollution and promote the safe use of pesticides.

A cooperative advertising program should be organized by the Ministry of Agriculture and Fisheries and different Agricultural Departments within the United Arab Emirates, to promote a balanced view on the uses and benefits of pesticides to the community.

The results of these studies indicated that, is no serious cases of pesticide contamination were detected in the foodstuffs under investigation. However there is no scientific research center conducting routine programs for monitoring pesticide residues in the UAE. Therefore, a recommendation can be made to establish a center of this type, to provide routine monitoring of the produce available to the public in this nation.

As it will take some time to establish such a center, in the meantime, short cooperative studies designed to regularly monitor pesticide residue levels in foodstuffs should be conducted. These studies should be expanded to include a wider range of fruit and vegetables and also to include a wider range of pesticides. Such work can be done with the cooperation of:

- The Ministry of Agriculture and Fisheries.
- Food Quality Labs in each emirate.

- The Environmental Research and Wildlife Development Agency (ERWDA).
- The Federal Environmental Agency (FEA).

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