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Risk Assessment of Commonly Used Major Pesticides for Tomato (*Solanum lycopersicum* L.) Cultivation in Bangladesh

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Abstract:

The aim of the present study was risk assessment that is hazard characterization and human exposure assessment of chemically treated tomato available in different production areas of Bangladesh. To do the risk assessment primarily a list of available pesticides in three different region of Bangladesh (Mymensingh, Narshindgdi and Jessore) was prepared by field visit and survey. Secondarily to determine the potential health risks associated with the exposures to these pesticides a scenario based on MSDS (material safety data sheet) evaluation was given. Moreover, ADI (acceptable daily intake), MRL (maximum residue level) and RfD (reference dose) value of agro-chemicals were also used which were referred by different organizations like WHO, EPA, FDA, EFSA, FAO, Codex. According to the field survey, most common agro-chemicals were taken to the study. All the pesticides available in the markets were found as authorized pesticides and none of them were found to be extremely hazardous according to the WHO recommended classification except Carbofuran. The present study indicates that there is a high chance to have residual effects of pesticides in tomato as a result of pre-harvest or postharvest application. Most of the farmers do not know about health risk issue of using agro-chemicals. It is important to aware the farmers to follow the recommended dose of registered pesticides and the consumers to proper handling and processing of tomato for safe consumption. Information on health risk, exposure assessment was also highlighted for public awareness. Suggestions were provided on the handling and processing such as washing, cooking, boiling, packing, storage etc. for the safety of the consumers. Farmers use both recommended and non-recommended pesticides for tomato production. In most cases farmers do not follow the recommended dose and rational pesticide application. Among the most commonly used pesticides, Carbofuran was found to be highly hazardous.

Keywords: ADI; Assessment; Pesticide residue, MRL; survey; MSDS; RfD; WHO

Introduction

Tomato (*Solanum lycopersicum L.*), which is botanically a fruit and not a vegetable, is loaded with all kinds of health benefits for the body. One of the most well known tomato- eating benefit is its lycopene content. Tomatoes are equally as nutritious as they are in other variable forms. It plays a vital role in providing a substantial quantity of vitamin C and vitamin A in human diet **[1].** Tomato is the most consumable vegetable occupying the top of the list as canned vegetable having multiple uses **[2]**. It is also suitable to grow in our agro-climatic condition. However, our average population has nutritional deficiency due to the traditional rice based food habit and lack of knowledge about balance diet. In addition food adulteration news via media is discouraging us to take fruit regularly. Proper science based risk assessment is essential to evaluate whether the agro-chemicals used for cultivation is actually threat for consumers during the time of consumption. Pesticide poisoning is a global health problem and it is more prevalent in countries like Bangladesh due to the non-judicial use. The incidence of pesticide poisoning is increasing according to the existing reports and it is estimated that about 5 million people die every year as a result of intentional, accidental and occupational exposure worldwide **[3]**. To combat insect pests and diseases of tomato and to achieve higher production, many pesticides are used that may leave certain amounts of residues on crops. Farmers tend to spray vegetables up to the time of harvest, and then transport directly to market with no waiting period. These create a very significant potential for pesticide residues causing negative health effects on consumers **[4]** Depending on the situation, pesticides could enter body by any one or all these routes.

Typical sources of pesticide exposure include food on which we are giving stress. Because most of the foods we eat have been grown with the use of pesticides. Therefore, pesticides residues may be present inside or in the surface of these foods. In one hand we have food crisis, over population on the other hand we have problem on safety. So, risk assessment (i.e. hazard identification, hazard characterization, exposure assessment and risk characterization) for food safety is a burning national issue. Survey reports conducted **[5,6,7]** at different locations of Bangladesh indicated that the farmers spray pesticide in their vegetable field irrationally, sometimes every day or in each alternate day. Due to the lack of knowledge and non-availability of sustainable alternatives to pesticide, farmers of Bangladesh become dependent on pesticide for crop production. Excessive and non-judicious use of pesticide has raised several environmental and social issues, as well as, destruction of agricultural ecosystem and development of resistance in insect pest, pathogens and weeds **[8]**. In Bangladesh, it is assumed that adulteration of pesticide is one of the major causes of such extensive use of pesticide. In the country report originated by FAO (2015) Corporate Document Repository, it is reported that the regulatory scheme for pesticide registration is systematic. But in practice, there are gaps between policies and implementation. While the intent of the ordinance and rules to monitor formulations and residue is commendable, the lack of facilities and trained analysts does not allow proper monitoring. Thus, specification of pesticides on the market may differ from those registered. So, concern on the purity in respect of active ingredient of the marketed brands of pesticides is therefore, likely key factor for repeated use of pesticides in vegetables. Due to absence or little amount of active material in the formulated pesticides, they do not work against insect pests and the farmers use more pesticide for better result **[9]**. Due to impurity of pesticide and low amount of active ingredient, farmers use more than recommended dose which are labeled and pest became resistant to that pesticide rapidly. According to this viewpoint, it has become significant to evaluate the brands of pesticide for quantification of their active ingredient (AI). So, the basic research objectives were: To make a list of available agro-chemicals used during the cultivation of tomato, to characterize the hazardous effect of pesticides, to evaluate their exposure and predict the theoretical risk.

Materials and Methods

For hazard identification a list of available agrochemicals generally used during the cultivation/harvest of tomato was prepared based on the field visit to three different areas of Bangladesh: Mymensingh , Norshingdi and Jessore. During field visit, Farmers' interview was conducted following a formal set of questionnaire. Further information was also collected by visiting Upazila Agricultural Officer, Agriculture Extension Officer and different pesticide shops. For hazard characterization and risk assessment the material safety data (MSDS) of registered and survey based agro-chemicals was compared and evaluated. Further evaluation was done via the material of the different authentic international organization's website (such as FDA, EFSA, WHO). The

degradation properties of those agro-chemicals which are influenced different post-harvest activity, packaging and transportation method was also considered **[10,11]**.

Result and Discussion

Risk and Exposure Assessment of Major Pesticides

Sulphur

In its native form, sulphur is an abundant, yellow crystalline solid. It can be found as the pure element and as sulphide and sulphate minerals. Sulphur is probably the oldest known pest management product in use. It Prevents powdery mildew, rose black spot, scab, rusts, and other diseases. It Can be used as a dust, wettable powder, paste or liquid. Controls red mites in tomato, citrus and other widespread crops when sulphur dioxide is at high concentrations. Other insects affected include white fly, thrips, some Homoptera, and gall midges. It does not subject to hazardous polymerization. Permissible exposure limit (PEL) has not been established by OSHA. Threshold limit value is 1ppm according to ACGIH. Sulphur is classified as class-III (slightly hazardous) according to WHO recommended hazard classification. In case of toxicity, large doses (15 grams) by mouth may lead to hydrogen sulfide production in the body, chiefly due to bacterial action within the colon. Rat-oral LD50= 175 mg/kg. Prolonged inhalation of dust over several years may cause respiratory disease, complicated by emphysema and bronchiectasis. Asthma and inflammation of the frontal and maxillary sinuses are frequent complications. Pulmonary function may be reduced showing increased, oxygen consumption, reduced respiratory volume, and impaired carbon dioxide diffusion capacity. Radiological examinations have revealed irregular opacities in the lungs and nodulation. ADI of sulphur is 200mg/kg body weight/day (EFSA), no MRL and RfD have been found. (Source: MSDS of Hovensa of West Liberty University-USA, Sigma-Aldrich-Germany, HPM-India, Rayfull-China, Nagarjuna Agrichem-India, Mingdou Agrichem-China, Chemical initiatives-South Africa etc).

Carbendazim

Carbendazim is one of the most widely used fungicides in tomato. It is a broad-spectrum benzimidazole fungicide and a metabolite of benomyl. It is stable in acids, forming water soluble salts. Half life in soil is 22-54 days. Ample evidence exists from experimentation that reduced human fertility is directly caused by exposure to the material. Ample evidence exists, from results in experimentation that developmental disorders are directly caused by human exposure to the material. Exposure to the material may result in a possible risk of irreversible effects. The material may produce mutagenic effects in man. Oral (rat) LD50: 6400 mg/kg Dermal (rat) LD50: 2000 mg/kg. ADI ranges from 0.01 to 0.08 mg/kg bw/day by (from table 6) and MRL value is 0.8 mg/kg (EFSA). RfD is 0.025 mg/kg. (Source: MSDS of Hovensa of West Liberty University-USA, Sigma-Aldrich-Germany, HPM-India, Rayfull-China, Nagarjuna Agrichem-India, Mingdou Agrichem-China, Chemical initiatives-South Africa etc).

Iprodione:

Iprodione is a dicarboximide contact fungicide with protective and curative action. It is a new member of neonicotinoid pesticides. It is Stable under normal conditions of use. PEL and TLV have not been established. Prolonged overexposure to iprodione can cause effects to liver, kidneys, and reproductive system. Iprodione produced benign testicular tumors in rats and benign liver and ovary tumors in mice when tested at a maximum tolerated dose. Overexposure to propylene glycol has been associated with kidney toxicity, liver toxicity (animals) and lactic acidosis. Oral: Rat LD50: 3,125 mg/kg (female) (estimated based on mortalities for doses tested) Dermal: Rat LD50: >5,000 mg/kg Inhalation: Rat 4-hr LC50: >2.09 mg/L.ADI ranges from 0.04-0.24 mg/kg-bw/day and MRL ranges from 01.5-6mg/kg. No RfD has been established. Oral LD50(rat) : >5000mg/kg. (Source: MSDS of Hovensa of West Liberty University-USA, Sigma-Aldrich-Germany, HPM-India, Rayfull-China, Nagarjuna Agrichem-India, Mingdou Agrichem-China, Chemical initiatives-South Africa etc).

Mancozeb

Mancozeb is a dithiocarbamate non-systemic agricultural fungicide with multi-site, protective action on contact. It is a combination of two other dithiocarbamates: maneb and zineb. It is classified as class U according to WHO recommended hazard classification. PEL and TLV have not been established. Half life in soil is 0.1-18

days. A two-year feeding study of mancozeb in rats produced an increased incidence of thyroid tumors at 750ppm (29mg/kg/day). No evidence of carcinogenicity was observed in long-term studies with mice. ADI ranges from 0.02-0.06 mg\kg-bw/day and MRL value ranges from 0.2-5 mg/kg (from the table).RfD is 0.05 mg/kg. (Source: MSDS of Hovensa of West Liberty University-USA, Sigma-Aldrich-Germany, HPM-India, Rayfull-China, Nagarjuna Agrichem-India, Mingdou Agrichem-China, Chemical initiatives-South Africa etc).

Mancozeb + Metalaxyl

It is another widely used fungicide in tomato. This product is unlikely to react or decompose under normal storage conditions. Half life is 07-170 days. PEL and TLV have not been established. It is classified as class-III according to WHO recommended classification. Oral LD50 for rats >5000mg/kg. No toxicological effects were apparent in rats fed dietary doses of 5 mg/kg/day in a long-term study. Impaired thyroid function was observed as lower iodine uptake after 24 months in dogs fed doses of 2.5 and 25 mg/kg/day of Mancozeb, but not in those dogs fed 0.625 mg/kg/day. A major toxicological concern in situations of chronic exposure is the generation of ethylenethiourea (ETU) in the course of Mancozeb metabolism, and as a contaminant in Mancozeb production. ETU may also be produced when EBDCs are used on stored produce, or during cooking. In addition to having the potential to cause goiter, a condition in which the thyroid gland is enlarged, this metabolite has produced birth defects and cancer in experimental animals. ADI ranges from 0.02-0.08 mg/kg-bw/day (from the table) and no MRL value has been found. RfD is 0.06mg/kg. (Source: MSDS of Hovensa of West Liberty University-USA, Sigma-Aldrich-Germany, HPM-India, Rayfull-China, Nagarjuna Agrichem-India, Mingdou Agrichem-China, Chemical initiatives-South Africa etc).

Malathion

Malathion belongs to the group of pesticides known as organophosphates, the same organophosphates weaponized in World War II for use as nerve agents. Malathion behaves similarly in pests, disrupting their nervous systems to the point of death. Although malathion controls numerous insect species, it's commonly used to control aphids (Aphidoidea spp.) and spider mites (Tetranychus urticae) on tomato plants (Lycopersicon esculentum). It is stable and hazardous polymerization will not occur. Half life in soil is 01-25 days. PEL is 15mg/m^3 and TLV is 1mg/m^3 (ACGIH). It is classified as class-III according to WHO recommended classification. Oral (rat) LD50: 290 mg/kg, Dermal (rat) LD50: 4444 mg/kg. Not classifiable as to its carcinogenicity to humans. Evidence of carcinogenicity may be inadequate or limited in animal testing. ADI ranges from 0.03-0.08 mg/kg-bw/day and MRL ranges from 0.19-4 mg/kg (from the table).RfD is 0.02 mg/kg. (Source: MSDS of Hovensa of West Liberty University-USA, Sigma-Aldrich-Germany, HPM-India, Rayfull-China, Nagarjuna Agrichem-India, Mingdou Agrichem-China, Chemical initiatives-South Africa etc).

Chlorpyrifos

Chlorpyrifos (IUPAC name: O, O-diethyl O-3,5,6-trichloropyridin-2-yl phosphorothioate) is a crystalline organophosphate insecticide, acaracide and miticide. Chlorpyrifos is moderately toxic to humans, and exposure has been linked to neurological effects, persistent developmental disorders and autoimmune disorders. Exposure during pregnancy retards the mental development of children, and most home use was banned in 2001 in the U.S. It is stable under recommended storage condition. Half life in soil is 11-141 days. PEL is 0.2mg/m^3 (OSHA) and TLV is 0.2mg/m^3 (ACGIH).It is classified as class II (Moderately hazardous) by WHO. Acute oral LD50 for rat : 82 mg/kg .Acute dermal LD50 for rat: 203 mg/kg. Repeated or prolonged exposure to organophosphates may result in the same effects as acute exposure including the delayed symptoms. Other effects reported in workers repeatedly exposed include impaired memory and concentration, disorientation, severe depressions, irritability, confusion, headache, speech difficulties, delayed reaction times, nightmares, sleepwalking, and drowsiness or insomnia. An influenza-like condition with headache, nausea, weakness, loss of appetite, and malaise has also been reported. The EPA's acceptable daily dose is 0.3 micrograms/kg/day. MRL value is 0.06(EFSA) and 0.5(CODEX) mg/kg. RfD is 0.005 mg/kg. (Source: MSDS of Hovensa of West Liberty University-USA, Sigma-Aldrich-Germany, HPM-India, Rayfull-China, Nagarjuna Agrichem-India, Mingdou Agrichem-China, Chemical initiatives-South Africa etc).

Carbofuran

Carbofuran is one of the most toxic carbamate pesticides. It is marketed under the trade names Furadan, Carbofuran is highly toxic to vertebrates with an oral LD50 of 8–14 mg/kg in rats and 19 mg/kg in dogs. It is

stable and hazardous polymeraization will not occur. Half life in soil is 3-60 days. PEL is 0.3mg/m^3 (OSHA) and TLV is 0.1mg/m^3 (ACGIH). IT is classified as Ib (highly hazardous) by WHO. Prolonged or repeated exposure increases the risk. Possible risk of irreversible effects may cause adverse effects on the bone marrow and blood-forming system. ADI is 0.00015mg/kg-bw/day (EFSA) and MRL value is 0.02-0.5 mg/kg.RfD is 0.005 mg/kg. (Source: MSDS of Hovensa of West Liberty University-USA, Sigma-Aldrich-Germany, HPM-India, Rayfull-China, Nagarjuna Agrichem-India, Mingdou Agrichem-China, Chemical initiatives-South Africa etc).

Carbosulfan

Carbosulfan is an organic compound adherent to the carbamate class. At normal conditions, It is not very stable; it decomposes slowly at room temperature. Its solubility in water is low but it is miscible with xylene, hexane, chloroform, dichloromethane, methanol and acetone. Half life in soil is 1-5 days. PEL and TLV have not been established. It is classified as class II (Moderately hazardous) by WHO. Acute oral toxicity: LD50 rat Dose: > 1,257.9 mg/kg. Acute dermal toxicity: LD50. No component of this product present at levels greater than or equal to 0.1% is identified as probable, possible or confirmed human carcinogen or potential carcinogen.(IARC, OSHA,NTP,ACGIH). ADI is 0.005 mg/kg-bw/day (EFSA) and MRL value is 0.05-0.1(from the table).RfD is 0.00007mg/kg. (Source: MSDS of Hovensa of West Liberty University-USA, Sigma Aldrich-Germany, HPM-India, Rayfull-China, Nagarjuna Agrichem-India, Mingdou Agrichem-China, Chemical initiatives-South Africa etc).

Cartap

Cartap is a chemical compound from the group of thiocarbamates. It is considered stable for a period of 2 years in normal air, warehouse and light conditions, if kept in closed container. Half life in soil is 2-7 days. PEL and TLV have not been established. It is classified as class II (Moderately hazardous) by WHO. Acute oral LD50: Big female rat, 126mg/kg big male rat, 126mg/kg .Acute dermal LD50: Male, female rat : > 2000mg/kg. Animal studies did not detect any carcinogenic effects. No human information available. No ADI, MRL and RfD value is available for cartap. (Source: MSDS of Hovensa of West Liberty University-USA, Sigma-Aldrich-Germany, HPM-India, Rayfull-China, Nagarjuna Agrichem-India, Mingdou Agrichem-China, Chemical initiatives-South Africa etc).

Diazinon

Diazinon is a synthetic chemical substance with a broad spectrum intertidal activity (Sarabia et al., 2009). Diazinon functions as an acetylcholinesterase (AChE) inhibitor. It is stable and hazardous polymeraization will not occur. Half life in soil is 21-103 days. PEL has not been established. TLV is 0.01 mg/m^3 (ACGIH). It is classified as class II (Moderately hazardous) by WHO. Acute Oral LD50 (rat): 66 mg/kg. Not listed in OSHA, NTP, or IARC. Diazinon is classified by ACGIH as TLV-A4: Not Classifiable as a Human Carcinogen. No ADI value is available. MRL value is 0.5 mg/kg (Codex). RfD is 0.0025 mg/kg. (Source: MSDS of Hovensa of West Liberty University-USA, Sigma-Aldrich-Germany, HPM-India, Rayfull China, Nagarjuna Agrichem-India, Mingdou Agrichem-China, Chemical initiatives-South Africa etc) **(Table 1- Table 11).**

Types of pesticides	Common name	Trade name	Company	Pest/Disease	Recommended dose	Farmer's practice dose
Miticide	**Sulpher**	**Thiovit 80WG**	**Syngenta BD. Ltd.**	**wilt**	**2.25kg**	**2g/L of water**
		Monovit 80WP	Mimpex agrochemicals Ltd.	wilt	2g/L of water	
		Hivit 80WDG	S.I. Agro International	Early Blight	2g/L of water	

Fungicide	Carbendazim	Aimcozim 50WP	ACI	Seedling rot	2g/L of water	2g/L of water
		Bavistin DF	BASF bd.	Seedling rot	1g/L of water	
		Genuine 50WP	SAM agro chemical	wilt	2g/L of water	
		cindazim 50WP	Shetu corp.	wilt	2g/L of water	
		Nayan 50WP	Anika enterprise	Seedling rot	1g/kg of seed	
		Zimper 50WP	Prime Agro Ltd.	wilt	2g/L of water	
Fungicide	Carbendazim	Mine 50WP	S.I. Agro International	Early blight	2g/L of water	2g/L of water
		Qubee 50WP	Asia Trade international	wilt	2g/L of water	
		Ravistin 50 WP	Raven aqua agriculture	wilt	2g/L of water	
	Copper oxychloride	Oxivit 50WP	SAM agro chemical	Early blight	3.5g/L	no clear information
		Pipertox 50WP	Agribusiness International	Early and late blight	4g/L	
		Baicoper 50WP	BD. Agricultural Industries.	Late blight	2g/L	
	Iprodione	Curate 50WP	Crop protection and care center	Early blight	2g/L	1g/L
		Agrodione 50WP	Partex agro Ltd.	Early blight	2g/L	no clear information

Fungicide	Mancozeb	Edcozeb 80WP	Sea trade fertilizer Ltd.	Early blight	2g/L	1g/L
		Razland 80WP	ACI	Early and late blight	2g/L	
		Suncozeb 80EP	Shetu Corp.	Early and late blight	2g/L	
		Cozeb 80WP	Alpha agro Ltd.	Late blight	2g/L	
		McZidan 80WP	McDonalds agro Ltd.	Early blight	2g/L	
		Haymancozeb 80WP	Haychem BD. Ltd.	wilt	2g/L	
		mancovit 80 WP	Haychem BD. Ltd	Early blight	2g/L	
		Meena 80WP	East west chemicals	Early and late blight	2g/L	
		Bicozeb 80WP	Bismillah agro.	Early and late blight	2g/L	
		Kenkozeb	S.I. international	Early and late blight	2g/L	
Fungicide	Mancozeb	Percozeb	Perfect agro.	Alternaria blight	2g/L	1g/L
		Rexizeb 80WP	Rexico international	Alternaria blight	2g/L	
		Greenzeb 80WP	Green harvest Ltd.	Alternaria blight	2g/L	
		Goldman 80WP	Mary gold BD. Ltd.	Early and late blight	2g/L	
		Zazz 80WP	Syngenta	Early and late blight	2g/L	
		Cleanzeb 80WP	Lclean Agro	Early and late blight	2g/L	
		Nikizeb 80WP	Anika ent.	Early and late blight	2g/L	
		Aristrozeb 80WP	Aristrocat agro service	Early and late blight	2g/L	
	Mancozeb +Carbendazim	Companion	Auto crop care	Early blight	2g/L	no clear information
		Carcozrb 75WP	Sea trade int.	Early blight	2g/L	
Fungicide	Metiram complex	Polyram DF	BASF Bd.	Early and late blight	2kg	no clear information
	Propiconazol	Fungizol 250EC	Aranya crop care	Early and late blight	0.5ml/L	
	Propineb	Top noch 70WP	Haychem BD. Ltd.	Late blight	150-250gm	
	propineb+ Iprovalicarb Melody	Melody duo 66.8WP	Bayer crop science	Early blight	2g/L	
	Mancozeb+ Cymoxanil	Sunoxamil 72WP	McDonalds agro Ltd.	Early and late blight	2g/L	
		cymongold 72	Alpha agro	Late blight	1.5g/L	
	Mancozeb + Metalaxyl	Zhe-Metalex 72 WP	Sea trade int.	Late blight	2kg	2g/L

		Metaril 72 WP	Auto crop care	Early blight	2g/L	
		Unilux 72 WP	United phosphorous Ltd.	Early blight	2.50kg	
		Haymaxyl MZ 72 WP	Haychem BD. Ltd.	Late blight	2g/L	
Fungicide	Mancozeb + Metalaxyl	nuben 72 WP	ACI	Early and late blight	2g/L	2g/L
		Evamil 72 WP	E.H. agrovet ltd.	Early blight	2g/L	
		Najah 72 WP	Intefa	Early and late blight	2g/L	
		Orion 72WP	Maitri agro	Early and late blight	2g/L	
		Ridomil gold MZ 68WG	Syngenta	Early and late blight	2g/L	
		Mancosil 72WP	Square pharma	Early blight	2g/L	
		Matco 72WP	Autocrop care	Early blight	2g/L	
	copper hydroxide	Champion 77WP	Petrochem BD ltd.	Late blight	2g/L	no clear information
		Win 77WP	Alpha agro	Early and late blight	2g/L	
	Quarternary Ammoniam	Timsen	Eon agro industries.	Early and late blight	2g/L	
	Propamocarb	Dodo 72 SL	Alpha agro	Early and late blight	2g/L	
Insecticide	Alpha cypermethrin	Mig 5 EC	Alpha agro	Aphid	1ml/L	no clear information
	Lamda cyhalothrin	Vajra 2.5EC	United phosphorous Ltd.	Aphid	1ml/L	
	Emamectin benzate	Proclaim 5 SG	Syngenta	Fruit borer	1g/L	
		Aroster 5 SG	Aranya	Fruit borer	1g/L	
		Emacore 5 SG	Corbel	Fruit borer	1g/L	
		Salam 5 SG	Intefa	Fruit borer	1g/L	
		Dyna 5 SG	S.I. agro	Fruit borer	1g/L	
		Nil 5 SG	BD. Agro. Ind.	Fruit borer	1g/L	
	Fulbendiamite	Belt 24 WG	Bayer crop.	Fruit borer	0.4g/L	
	thiamethoxam +chloraniliplore	Volium flexi 300 SC	Syngenta	Fruit borer	0.5ml/L	
	Malathion	Malathion	Shetu Pesticide	Aphid, fruit borer	1.12L	1ml/L
Source: Bangladesh Crop Protection Association (BCPA)-2015.						

Table 1: List of recommended agro-chemicals used in tomato cultivation.

Type	Common Name	Trade Name	Recommended crop and dose	Farmer's Dose	Frequency (for week)
Miticide	Sulphur	Thiovit 80WG	Tomato-2.25kg/ha	2kg/ha	1
Fungicide	Iprodione	Rovral 50 WP	Mustard,Onion-1kg/ha	1kg/ha	2
	Mancozeb + Metalaxyl	Metazeb 72WP	Potato-2g/L of water	0.5-1kg/ha	1-2
		Ridomil Gold MZ 68 WG	Tomato-5gm/L of water	2kg/ha	1-2
	Carbendazim	Bavistin DF	Tomato-1gm/L of water	1kg/ha	2
	Mancozeb	Dithane M 45	Potato,jute, peanut-2.20kg/ha	1-2kg/ha	2
Insecticide	Carbosulfan	Marshal 20 EC	Rice,cotton,brinjal-1.50L/ha	1-2L/ha	2
	Malathion	Malathion 57EC	Tomato-1.12L/ha	0.5L/ha	1
	Cartap	Cartap 50 SP	Rice-800gm-1.40kg/ha	2kg/ha	1-2
	Chlorpyrifos	Dursban 20 EC	Rice,tea,potato, cotton,sugarcane 1-10L/ha	2L/ha	1
	Diazinon	Basudin 10GR	Rice-16.80kg/ha	1kg/ha	1-2
		Diazinon 60 EC	Vegetables-1.70L/ha	1L/ha	1
	Carbofuran	Furadan 5G	Rice,sugarcane, potato-10-40kg/ha	1kg/ha	2
Source: Bangladesh Crop Protection Association (BCPA)-2015 for recommended crop and dose.					

Table 2: List of agro-chemicals used at farmer's level based on survey.

Product	Type	Molecular formula	CAS no.	Stability	Half life in soil(D)	Exposure limits
Sulpher	Miticide	S	7704-34-9	Stable. Hazardous polymerization will not occur.	Stable	PEL=None established (OSHA) TLV=1ppm (ACGIH)
Carbendazim	Fungicide	$C_9H_9N_3O_2$	10605-21-7	Stable in Acids,forming water soluble salts	22-54	TLV=none established (ACGIH)
Iprodione		$C_{13}H_{13}Cl_2N_3O_3$	36734-19-7	Stable under normal conditions of use	84	PEL=None established (OSHA) TLV=none established (ACGIH)
Mancozeb	Fungicide	$(C_4H_6Mn_2S_4)x$ Zny	8010-01-7	Conditions to avoid: heat, water and fire. Hazardous reaction: will not occur	0.1-18	PEL=None established (OSHA) TLV=none established (ACGIH)
Mancozeb + Metalaxyl		$(C_4H_6Mn_2S_4)x$ Zny + $C_{15}H_{21}NO_4$	Mancozeb 8010-01-7 Metalaxyl 57837-19-1	This product is unlikely to react or decompose under normal storage conditions	07-170	PEL=None established (OSHA) TLV=none established (ACGIH)

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Product	Type	Molecular formula	CAS no.	Stability	Half life in soil(D)	Exposure limits
Malathion	Insecticide	$C_{10}H_{19}O_6PS_2$	121-75-5	Stable. Hazardous polymerization will not occur.	01-25	PEL= 15 mg/m3 TWA; Skin TLV=1mg/m^3 TWA Inhalable fraction, Vapor and aerosol. (ACGIH)
Chlorpyrifos	Insecticide	$C_9H_{11}Cl_3NO_3PS$	2921-88-2	Stable under recommended storage conditions.	11-141	PEL=0.2mg/m^3, Skin (OSHA) TLV=0.2mg/m^3, Skin (ACGIH)
Carbofuran		$C_{12}H_{15}NO_3$	1563-66-2	Stable. Hazardous polymerization will not occur.	3-60	PEL=TWA:0.1mg/m3 (OSHA) TLV= 0.1 mg/m3 inhalable fraction and vapor (ACGIH)
Carbosulfan		$C_{20}H_{32}N_2O_3S$	55285-14-8	Stable under recommended storage conditions.	1-5	PEL=None established (OSHA) TLV=none established (ACGIH)
Cartap	Inecticide	$C_7H1_6ClN_3O_2S_2$	15263-52-2	Considered stable for a period of 2 years in normal air, warehouse and light conditions, if kept in closed container.	2-7	PEL=None established (OSHA) TLV=none established (ACGIH)
Diazinon		$C_{12}H_{21}N_2O_3PS$	333-41-5	Stable. Hazardous polymerization will not occur.	21-103	PEL=None established (OSHA) TLV=0.01mg/m3 (Skin) (ACGIH)

PEL: Permissible Exposure Limit, TLV: Threshold Limit Value, TWA: Time Weighted Average, OSHA: Occupational Safety and Hazard Association, ACGIH: American Conference of Govt. Industrial Hygienists. (MSDS source: Hovensa of West Liberty University-USA, Sigma-Aldrich-Germany,HPM-India,Rayfull-China, Nagarjuna Agrichem-India, Mingdou Agrichem-China, Chemical initiatives-South Africa etc).

Table 3: MSDS Evaluation of Commonly Used Agro-chemicals in Tomato.

Product	Type	WHO recommended hazard classification	Acute toxicity	Chronic effects and Carcinogenicity
Sulpher	Miticide	III	Large doses (15 grams) by mouth may lead to hydrogen sulfide production in the body, chiefly due to Bacterial action within the colon. Rat-oral LD50 = 175 mg/kg.	Prolonged inhalation of dust over several years may cause respiratory disease, complicated by emphysema and bronchiectasis. Asthma and inflammation of the frontal and maxillary sinuses are frequent complications. Pulmonary function may be reduced showing increased, oxygen consumption, reduced respiratory volume, and impaired carbon dioxide diffusion capacity. Radiological examinations have revealed irregular opacities in the lungs and nodulation.
Carbendazim	Fungicide	U	Oral (rat) LD50: 6400 mg/kg Dermal (rat) LD50: 2000 mg/kg. Dermal (rabbit) LD50: 8500 mg/kg Oral (dog) LD50: >2500 mg/kg	Ample evidence exists from experimentation that reduced human fertility is directly caused by exposure to the material. Ample evidence exists, from results in experimentation that developmental disorders are directly caused by human exposure to the material. Exposure to the material may result in a possible risk of irreversible effects. The material may produce mutagenic effects in man.

(Continued)

Product	Type	WHO recommended hazard classification	Acute toxicity	Chronic effects and Carcinogenicity
Iprodione	Fungicide	III	Oral: Rat LD50: 3,125 mg/kg (female) (estimated based on mortalities for doses tested) Dermal: Rat LD50: >5,000 mg/kg Inhalation: Rat 4-hr LC50: >2.09 mg/L Eye Irritation: Rabbit: Mildly irritating Skin Irritation: Rabbit: Slightly irritating Skin Sensitization: Not a contact sensitizer in guinea pigs following repeated skin exposure.	Prolonged overexposure to iprodione can cause effects to liver, kidneys, and reproductive system. Iprodione produced benign testicular tumors in rats and benign liver and ovary tumors in mice when tested at a maximum tolerated dose. Overexposure to propylene glycol has been associated with kidney toxicity, liver toxicity (animals) and lactic acidosis

Mancozeb	Fungicide	U	Oral LD50(rat): >5000mg/kg Dermal LD50(rabbit): >5000mg/kg Skin irritation (rabbit): practically non-irritating Eye irritation(rabbit): not irritating(EEC Classification) Moderately irritating(US Classification) Inhalation LC50 (rat): >5.14mg/L for 4 hr.	A two-year feeding study of mancozeb in rats produced an increased incidence of thyroid tumors at 750ppm (29mg/kg/day). No evidence of carcinogenicity was observed in long-term studies with mice.

(Continued)

Product	Type	WHO recommended hazard classification	Acute toxicity	Chronic effects and Carcinogenicity
Mancozeb+ Metalaxyl	Fungicide	III	Oral LD50 for rats >5000mg/kg. Low toxicity. Dermal LD50 for rabbits >5000mg/kg. Low toxicity. Inhalation LC50 for rats >2.0mg/L for 4 hours. Low toxicity. Skin irritation: Practically non-irritating (rabbits) Eye irritation: Irritation (rabbits)	No toxicological effects were apparent in rats fed dietary doses of 5 mg/kg/day in a long-term study. Impaired thyroid function was observed as lower iodine uptake after 24 months in dogs fed doses of 2.5 and 25 mg/kg/day of Mancozeb, but not in those dogs fed 0.625 mg/kg/day. A major toxicological concern in situations of chronic exposure is the generation of ethylenethiourea (ETU) in the course of Mancozeb metabolism, and as a contaminant in Mancozeb production. In addition to having the potential to cause goitre, a condition in which the thyroid gland is enlarged, this metabolite has produced birth defects and cancer in experimental animals.

(Continued)

Product	Type	WHO recommended hazard classification	Acute toxicity	Chronic effects and Carcinogenicity
Malathion	Insecticide	III	Oral (rat) LD50: 290 mg/kg Inhalation (rat) LC50: 84.6 mg/m"/4h Dermal (rabbit) LD50: 4100 mg/kg Dermal (rat) LD50: 4444 mg/kg	NOT classifiable as to its carcinogenicity to humans. Evidence of carcinogenicity may be inadequate or limited in animal testing.
Chlorpyrifos	Insecticide	II	Acute oral LD50 for rat：82 mg/kg Acute dermal LD50 for rat: 203 mg/kg Inhalation LD50 (4h) for rat: 630mg/m3	Repeated or prolonged exposure to organophosphates may result in the same effects as acute exposure including the delayed symptoms. Other effects reported in workers repeatedly exposed include impaired memory and concentration, disorientation, severe depressions, irritability, confusion, headache, speech difficulties, delayed reaction times, nightmares, sleepwalking, and drowsiness or insomnia.

(Cont'd)

Product	Type	WHO recommended hazard classification	Acute toxicity	Chronic effects and Carcinogenicity
Carbofuran	Insecticide	Ib	Rat Acute Oral: LD50 = 167 mg/kg Rabbit Acute Dermal: LD50 > 2000 mg/kg Rat Acute Inhalation: LC50 = 1.18 mg/L/4 hr	Prolonged or repeated exposure increases the risk. Possible risk of irreversible effects. May cause adverse effects on the bone marrow and blood-forming system.

Carbosulfan	Insecticide	II	Acute oral toxicity: LD50 rat Dose: > 1,257.9 mg/kg Acute dermal toxicity: LD50 rabbit Dose: > 2,000 mg/kg Acute inhalation toxicity: LC50 rat	No component of this product present at levels greater than or equal to 0.1% is identified as probable, possible or confirmed human carcinogen or potential carcinogen.(IARC,OSHA,NTP,ACGIH)
Cartap	Insecticide	II	Acute oral LD50: Big female rat, 126mg/kg Big male rat, 126mg/kg Acute dermal LD50: Male, female rat : > 2000mg/kg	Animal studies did not detect any carcinogenic effects. No human information available.
Diazinon	Insecticide	II	Acute Oral LD50 (rat): 66 mg/kg (Diazinon technical) Acute Dermal LD50 (rabbit): 1800 mg/kg (Diazinon technical) Inhalation LC50 (male rat): >3500 mg/L (4 HR)	Not listed in OSHA, NTP, or IARC. Diazinon is classified by ACGIH as TLV-A4: Not Classifiable as a Human Carcinogen.

Ia = Extremely hazardous; Ib = Highly hazardous; II = Moderately hazardous;
III = slightly hazardous; U = Unlikely to present acute hazard in normal use;
FM = Fumigant, not classified; O = Obsolete as pesticide, not classified.
(The WHO Recommended Classification of Pesticides by Hazard)
NTP: National Toxicological Program, IARC: International Agency for Research on Cancer.
MSDS source: Hovensa of West Liberty University,Sigma-Aldrich,HPM-India,Rayfull,Santaruz biotechnology,Nagarjuna Agrichem, Mingdou Agrichem, Chemical initiatives etc.)

Table 4: Hazard and Toxicological information.

Sl No	Product Name	Type	Molecular Formula	Unit (mg/kg bw/day)				
				FDA	EFSA	Codex	FAO	WHO
1	Sulphur	Miticide	S	NF	200	NF	NF	NF
2	Carbendazim	Fungicide	$C_9H_9N_3O_2$	0.08	0.02	0-0.03	0-0.01	NF
3	Iprodione	Fungicide	$(C_4H_6MnN_2S_4)x$ $(Zn)_y$	0.04	0.06	0.24	0-0.06	NF
4	Mancozeb	Fungicide	$(C_4H_6MnN_2S_4)_x(Zn)_y$ + $C_{15}H_{21}NO_4$	0.06	0.05	0.02	0.04	NF
5	Mancozeb + Metalaxyl	Fungicide	$C10H19O_6PS_2$	0.06-0.08	0.05-0.02	NF	NF	NF
6	Malathion	Insecticide	$C_{10}H_{19}O_6PS_2$	NF	NF	NF	NF	NF
7	Chloropyrifos	Insecticide	$C_9H_{11}Cl_3NO_3PS$	NF	NF	NF	NF	NF

8	Cartap	Insecticide	$C_{12}H_{15}NO_3$	NF	NF	NF	NF	NF
9	Diazinon	Insecticide	$C_{20}H_{32}N_2O_3S$	NF	NF	NF	NF	NF
10	Carbofuran	Insecticide	$C_7H1_6ClN_3O_2S_2$	NF	0.00015	NF	NF	NF
11	Carbosulfan	Insecticide	$C_{12}H_{21}N_2O_3PS$	NF	0.005	NF	NF	NF

FDA: U.S. Food and Drug Administration, **EFSA:** European Food Safety Authority, **Codex:**Codex Alimentarious **FAO:** Food and Agricultural Organization, **WHO:** World Health Organization. **NF:** Not Found.

Table 5: ADI (Acceptable Daily Intake) Value.

S.No	Product Name	Type	Molecular Formula	Unit (mg/kg)				
				FDA	EFSA	Codex	FAO	WHO
1	Sulphur	Miticide	S	NF	NF	NF	NF	NF
2	Carbendazim	Fungicide	$C_9H_9N_3O_2$	NF	0.08	NF	NF	NF
3	Iprodione	Fungicide	$(C_4H_6MnN_2S_4)x(Zn)_y$	NF	0.15	4.2	6	NF
4	Mancozeb	Fungicide	$(C_4H_6MnN_2S_4)_x(Zn)_y+C_{15}H_{21}NO_4$	0.2	0.2	2	0.05	NF
5	Mancozeb+ Metalaxyl	Fungicide	$C10H19O_6PS_2$	NF	NF	NF	NF	NF
6	Malathion	Insecticide	$C_{10}H_{19}O_6PS_2$	0.19	1	3	0.2	4
7	Chloropyrifos	Insecticide	$C_9H_{11}Cl_3NO_3PS$	NF	NF	NF	NF	NF
8	Cartap	Insecticide	$C_{12}H_{15}NO_3$	NF	NF	NF	NF	NF
9	Diazinon	Insecticide	$C_{20}H_{32}N_2O_3S$	NF	NF	0.5	NF	NF
10	Carbofuran	Insecticide	$C_7H1_6ClN_3O_2S_2$	0.2	0.5	0.02	NF	NF
11	Carbosulfan	Insecticide	$C_{12}H_{21}N_2O_3PS$	0.05	0.1	NF	NF	NF

FDA: U.S. Food and Drug Administration, **EFSA:** European Food Safety Authority, **Codex:** Codex Alimentarious, **FAO:** Food and Agricultural Organization, **WHO:** World Health Organization. **NF:** Not Found.

Table 6: MRL (Maximum Residue Limit) Value

Agro-chemicals	Reference dose (RfD) mg/kg/day
Sulphur	NF
Carbendazim	0.025
Iprodione	NF
Mancozeb	0.05
Mancozeb+Metalaxyl	0.06
Malathion	0.02
Chlorpyrifos	0.005
Carbofuran	0.005
Carbosulfan	0.00007
Cartap	NF
Diazinon	0.0025
Source: U.S. Environmental Protection Agency (EPA).	

Table 7: Refeence Dose (RfD).

SL	Location: Date: Mobile:
1.	Name:
2.	Father's name:
3.	Address:
4.	Occupation:
5.	Type of crop produce:
6.	Season of tomato cultivation:
7.	Varieties of tomato cultivated:

8.	Land area for tomato cultivation:
9.	Fertilizer used for tomato cultivation and their amount:
10.	Types and amount of pesticides used for tomato production:
11.	Time of pesticide application/spray:
12.	Agro-chemicals used other than pesticides:
13.	Place of pesticide collection/purchase:
14.	Any harm or injury occurrence in the body for using pesticides/agro-chemicals:
15.	Total production of tomato:
16.	Post harvest tomato preservation:
17.	Any chemical used for preservation:
18.	Marketing process:
19.	Any chemical used during marketing process:
20.	Duration of tomato preservation without using any chemical:
21.	Persons from whom suggestions for pesticide application had been taken:
22.	Name of pesticides that gave better performance:
23.	Any suggestion regarding better application method of pesticide:
24.	Interval between last pesticide application and harvesting day:
25.	Period of life cycle of tomato that requires more pesticide application:

Table 8: Questionnaire for Field Survey.

SL.	NAME	LOCATION	PESTICIDE	DOSE	FUNGICIDE	DOSE	SPRAY TIME	FREQUENCY
1.	MD. MOSTOFA	ACHINTYAPUR, GOURIPUR	CARTAP,MONIHOTOR	1-2g/L	METAZEB	1-2g/L	AFTER NOON	ONCE A WEEK
2.	MD. KHOKON MIA	ACHINTYAPUR, GOURIPUR	MALATHION,SUMITHIONCARTAP	0.5mL/L	METAZEB	0.5mL/L	AFTER NOON	TWICE A WEEK
3.	MD. ZIAUR RAHMAN	ACHINTYAPUR, GOURIPUR	CARTAP	2.5 g/L	METAZEB	2.5 g/L	AFTER NOON	ONCE A WEEK
4.	HAZRAT ALI	ACHINTYAPUR, GOURIPUR	MALATHION	0.5 mL/L	METAZEB	1 mg/L	AFTER NOON	ONCE A WEEK
5.	ZABBAR ALI	ACHINTYAPUR, GOURIPUR	MALATHION	1 mL/L	-	-	AFTER NOON	15 DAYS INTERVAL
6.	ABUL MIA	ACHINTYAPUR, GOURIPUR	-	0.5mL/L	-	0.5mL/L	AFTER NOON	15 DAYS INTERVAL
7.	MD. SAIFUL ISLAM	MORICHAR CHOR,ISHWARGONJ	FURADAN,DIAZINON	1g/L	-	-	AFTER NOON	TWICE A WEEK
8.	RONY	MORICHAR	MALATHION,	2g/L	-	2g/L	AFTER	ONCE A

	AHMED	CHOR,ISHWARGONJ	FURADAN				NOON	WEEK
9.	RUHUL AMIN	MORICHAR CHOR,ISHWARGONJ	FURADAN,DIAZINON	2g/L	-	2g/L	AFTER NOON	ONCE A WEEK
10.	MAKBUL MIA	POSHCHIM DHAPUNIA,GOURIPUR	-	1mL/L	-	1mL/L	AFTER NOON	20 DAYS INTERVAL
11.	MOBAROK HOSSAIN	POSHCHIM DHAPUNIA,GOURIPUR	-	1mL/L	-	1mL/L	AFTER NOON	10-15 DAYS INTERVAL
12.	MD. JASIM MIA	POSHCHIM DHAPUNIA,GOURIPUR	CARTAP	2g/L	-	2g/L	AFTER NOON	ONCE A WEEK
13.	MD. ABDUL MATIN	POSHCHIM DHAPUNIA,GOURIPUR	-	2mL/L	-	2mL/L	AFTER NOON	10-15DAYS INTERVAL

Table 9: Survey Report at a Glance (District: Mymensingh, Date: 05/07/15-06/07/15).

SL	NAME	LOCATION	INSECTICIDE	DOSE	FUNGICIDE	DOSE	SPRAY TIME	FREQUENCY
1.	EBADUL HAQUE	BAGHUTIA,ABHAYNAGAR	MARSHAL, MALATHION	0.5 mL/L	ROVRAL 50WP	0.5mL/L	AFTERNOON	ONCE A WEEK
2.	ANWAR HOSSAIN	BAGHUTIA,ABHAYNAGAR	MARSHAL	1mL/L	ROVRAL, RIDOMIL	1mL/L	AFTERNOON	ONCE A WEEK
3.	INDRAJIT GHOSH	DIAPARA, ABHAYNAGAR	-	1 mL/L	RIDOMIL	1mL/L	AFTERNOON	ONCE A WEEK
4.	ABDUL MAJID	GOTKHALI,JHIKORGACHI	FURADAN 5G	1g/L	ROVRAL	1 mL/L	AFTERNOON	TWICE A WEEK
5.	SAJEDUL ISLAM	GOTKHALI,JHIKORGACHI	CARTAP,MARSHAL	1-2g/L	ROVRAL, RIDOMIL	1-2g/L	AFTERNOON	TWICE A WEEK
6.	KABIRUL ISLAM	GOTKHALI,JHIKORGACHI	CARTAP	2g/L	RIDOMIL	2g/L	AFTERNOON	ONCE A WEEK
7.	MD. SHAHID	SADIPUR,CHOUGACHA	-	1mL/L	-	1mL/L	AFTERNOON	TWICE A WEEK

8.	MD. SWAPAN	SADIPUR,CHOUGACHA	FURADAN,CARTAP	2-3g/L	ROVRAL	2-3g/L	AFTERNOON	ONCE A WEEK
9.	SHAJAHAN MIA	JAHURPUR,BAGHARPARA	FURADAN	2-3g/L	ROVRAL	2-3g/L	AFTERNOON	TWICE A WEEK
10.	MOJU MIA	JAHURPUR,BAGHARPARA	FURADAN	2-3g/L	-	2-3g/L	AFTERNOON	TWICE A WEEK

Table 10: Survey Report at a Glance (District: Jessore, Date:03/10/15-07/10/15).

Table 11: Survey Report at a Glance (District: Narshingdi, Date: 01/08/15-02/08/15).

SL	NAME	LOCATION	PESTICIDE	DOSE	FUNGICIDE	DOSE	SPRAY TIME	FREQUENCY
1.	ABU BAKAR SIDDIK	CHORSINDUR,POLASH	CARTAP ,DURSBAN	2 g/L	BAVISTIN, RIDOMIL	2 g/L	MORNING	TWICE A WEEK
2.	MD. SALEH AHMED	CHORSINDUR,POLASH	CARTAP ,DURSBAN	2 g/L	BAVISTIN, RIDOMIL	2 g/L	AFTER NOON	TWICE A WEEK
3.	MD. AKHLAS MIA	CHORALINOGOR,POLASH	CARTAP	1gmL/L	BAVISTIN, RIDOMIL	2 g/L	AFTER NOON	ONCE A WEEK
4.	RAJORSHI NATH	PARULIA,POLASH	CARTAP ,DURSBAN	2 g/L	-	2 g/L	AFTER NOON	ONCE A WEEK
5.	ANISUR RAHMAN	CHORMODDHONOGOR ,BELABO	BASUDIN	1g/L	DITHANE M45	1-2g/L	AFTER NOON	TWICE A WEEK
6.	SOBHAN MOLLA	BAJNABO,BELABO	BASUDIN	1g/L	DITHANE M45	1g/L	AFTER NOON	ONCE A WEEK
7.	MD. ASHRAFUDDIN	BAJNABO,BELABO	BASUDIN	1g/L	DITHANE M45	1g/L	AFTER NOON	TWICE A WEEK
8.	ABUL KALAM AZAD	MATIARPARA, BELABO	BASUDIN,CARTAP	1-2g/L	RIDOMIL	2g/L	AFTER NOON	ONCE A WEEK
9.	MD. JAMALUDDIN	MATIARPARA, BELABO	BASUDIN	1-2g/L	DITHANE M45	1-2g/L	AFTER NOON	ONCE A WEEK
10.	ISHAK MIA	NARAYANPUR, BELABO	BASUDIN,CARTAP	1-2g/L	BAVISTIN, RIDOMIL	2g/L	AFTER NOON	TWICE A WEEK

Conclusion

The research was carried out to find out the risks associated with the major pesticides used for tomato cultivation in Bangladesh. The research included field survey in three different regions of Bangladesh namely Mymensingh, Narshingdi and Jessore. Results of field survey revealed that for tomato production farmers not only use pesticides

that are registered for tomato but also use other pesticides that are not recommended for tomato. The most commonly used pesticides were sulphur, carbendazim, iprodione, mancozeb, mancozeb+metalaxyl, malathion, chlorpyrifos, cartap, carbofuran, carbosulfan and diazinon. In most cases farmers do not follow rational use of pesticides. Therefore, risk assessment of these pesticides was carried out by MSDS evaluation. Carbofuran was classified as highly hazardous (Ib) by WHO. Several mitigation processes was mentioned for the safe consumption of tomato. As most of the pesticides after application remain in the outer surfaces and can penetrate in lesser amount, washing, peeling or trimming can be effective ways of pesticide removal. Washing with dilute salt (sodium chloride) solution is a convenient method to lower the load of contaminants from food surfaces particularly fruits and vegetables. Chlorine water and dilute solutions of other chemicals can be used for disinfection of Tomato. The heat treatment can be given in many ways including pasteurization, boiling, cooking etc. depending upon the nature of food and aim of processing. Boiling is effective in reducing the level of water-soluble pesticides. A set of processing techniques such as drying and dehydration, canning of fruits and vegetables, juice/concentrate preparation etc. can reduce the amount of residue in the final product depending upon a set of parameters employed and length of processing. The packing process before shipment to retail outlets is generally effective in removing pesticides that may be present on peel at the time of harvest. Dispassion of pesticides in tomato results better in room temperature than cold condition while storage. Farmers should follow the recommended dose of registered pesticides. On the other hand consumers also need to be aware of proper handling and processing of tomato and its byproducts for safe consumption.

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