Research Article

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ANALYSIS OF PESTICIDE RESIDUE LEVELS IN MARKET-AVAILABLE TOMATO SAMPLES IN BANGALORE, KARNATAKA, INDIA

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ABSTRACT

Introduction: Tomatoes are one of India's most important protective food crops. The plants typically grow 1-3 meters in height. The major Tomatoes-producing states are Bihar, Karnataka, Uttar Pradesh, Orissa, Andhra Pradesh, Maharashtra, Madhya Pradesh and West Bengal. Tomato is one of the vegetables used regularly in Indian culinary and India is one of the major countries which produce Tomatoes. In Karnataka, the major districts which grow tomatoes are Kolar, Mandya, Belagavi, Haveri, Davanagere, Chikkaballapur, and Bengaluru Rural. Long-term, low-dose exposure to pesticides has been found to be progressively associated with adverse health consequences in humans, including cancer, immunosuppression, hormone disruption, lowered IQ, and aberrant reproductive health. Hence, the study was conducted to evaluate pesticide residue in market samples of Tomatoes. Methodology: Tomatoes samples from 3 different major markets in Bangalore, namely the K.R market (KRM), Yeshwanthpur market (YM) and Madiwala market (MM), were collected and subjected to pesticide residue analysis at a food testing laboratory. Results: The study's results revealed that the presence of pesticide residue did not exceed maximum residue levels in all Tomatoes samples. Conclusion: Based on the study's findings, Tomatoes samples from all three market samples have pesticide residue below the quantification limit, or LOQ < 0.1 mg/kg. The superiority of the Ayurvedic treatment plan lies in its ability to heal cumulative damage through internal therapy and detoxification.

Keywords: Pesticide residue, Market samples, Tomato, Gara-visha (Artificial poison)

INTRODUCTION

Ayurveda places great emphasis on food, and it is also claimed that ingesting wholesome food will help avoid disease[1]. It is impossible to anticipate good health from these contaminated food products if the Ahara itself is impacted by harmful agents like pesticides. Getting high-quality food has grown harder these days due to increased adulteration and excessive pesticide use.

Ayurveda explains that the contamination of food with toxic substances can lead to many symptoms like paleness, reduced appetite, palpitation and so on[2]. Though mixing toxic substances, as told in classics like sweat and excreta[3] may look bizarre, the usage of pesticides and entry of these harmful substances through the food chain can be considered Gara-visha (artificial poison).

In recent years, using organic synthetic pesticides has become widespread for preventing, controlling and destroying pests. Despite their usefulness in increasing food production, the extensive use of pesticides during production, processing, storage, transport or marketing has led to environmental contamination, and pesticide residues reach the human body through the food chain.

In India, 51% of food commodities are contaminated with pesticide residues; out of these, 20% have pesticide residues above the maximum residue level values worldwide.

It has been observed that their long-term, low-dose exposure is increasingly linked to human health effects such as immune suppression, hormone disruption, diminished intelligence, reproductive abnormalities, and cancer[4].

Bengaluru, Karnataka, India, a densely populated metropolis, has a greater need for food goods. The farmer's production needs to be enough, and production losses must be minimal to meet increased demand. The use of different pesticides is one strategy to address the problem.

Understanding the quality of the food that the population frequently consumes is crucial. Therefore, the study aimed to determine whether pesticide residues on the vegetable samples exceed the maximum residue levels (MRLs).

Aim: This study aimed to assess the presence and levels of pesticide residues in commercially available Tomatoes samples in order to evaluate potential health risks.

Objectives

- To identify and quantify the types and levels of pesticide residues present in the collected Tomatoes samples using analytical techniques such as gas chromatography-mass spectrometry (GC-MS) and liquid chromatography-mass spectrometry (LC-MS).[5]
- To compare the detected pesticide residues with maximum residue limits (MRLs) established by regulatory agencies such as FSSR.

METHODOLOGY

Analysis of sample: The first group samples study for pesticide residue analysis (organophosphorus and organo chlorine compounds) was done at TUV India Pvt. limited lab Rajajinagar, Industrial town Bangalore, Karnataka, India.

The second group and third group sample study was done in an ALS testing lab in Jigani Bangalore, Karnataka, India.

Method of Collection of Data

Sample Collection: The market samples of Tomatoes were collected from vendors during business hours in respective markets in a sterile polythene bag.
The sample quantity taken for analysis was 1 kg.
The collected samples from 3 different markets were subjected to analytical study.

Sample Grouping
Group 1
Sample 1 – KRM fresh sample of Tomatoes without washing.
Sample 2 – KRM fresh sample of Tomatoes with thorough washing in running water.
Sample 3 – KRM fresh sample of Tomatoes with thorough washing with 2% of salt solution.
Sample 4 – KRM fresh sample of Tomatoes with thorough washing with lime solution.
Sample 5 – KRM fresh sample of Tomatoes soaking and washing with baking soda mixed in water for 20min.
Group 2
Sample 1 – YM – fresh sample of Tomatoes without washing.
Group 3
Sample 1 – MM – fresh sample of Tomatoes without washing.

Total number of sample analysis
Group 1 – 5 sample
Group 2 – 1 sample
Group 3 – 1 sample

Method of Analysis

Analytical study: The lab's standard operating procedures were considered. QuECHERS method (validation as per SANTE guidelines),[6] LCMSMS and GCMSMS methods[5,6] were used to analyse pesticide residue in given samples.

RESULTS

Table 1: Results of Group 1 market samples of Tomatoes

Test name	Results	Unit	LOQ/LOD	Limit as per FSSR: 2011
Difenoconazole	<LOQ	mg/kg	0.01	Max 0.2
Dimethomorph	<LOQ	mg/kg	0.01	Max 0.2
Fenamidone	<LOQ	mg/kg	0.01	Max 1.5
Fenazaquin	<LOQ	mg/kg	0.01	Max 0.01
Flubendiamide	<LOQ	mg/kg	0.01	Max 2.0
Imidacloprid	<LOQ	mg/kg	0.01	Max 1.0
Mandipropamid	<LOQ	mg/kg	0.01	Max 0.3
Metribuzin	<LOQ	mg/kg	0.01	Max 0.05
Novaluron	<LOQ	mg/kg	0.01	Max 0.01
Ametoctradin	<LOQ	mg/kg	0.01	Max 0.3
Azoxystrobin	<LOQ	mg/kg	0.01	Max 1.0
Chlorantraniliprole	<LOQ	mg/kg	0.01	Max 0.6
Cyantraniliprole	<LOQ	mg/kg	0.01	Max 0.5
Cyazofamid	<LOQ	mg/kg	0.01	Max 0.01
Pyraclostrobin	<LOQ	mg/kg	0.01	Max 0.3
Spiromesifen	<LOQ	mg/kg	0.01	Max 0.7
Tebuconazole	<LOQ	mg/kg	0.01	Max 2.0
Thiamethoxam	<LOQ	mg/kg	0.01	Max 0.70
Cymoxanil	<LOQ	mg/kg	0.01	Max 0.01
Ethephon	<LOQ	mg/kg	0.01	Max 2.0
Indoxacarb	<LOQ	mg/kg	0.01	Max 0.5
Lambdacyhalothrin	<LOQ	mg/kg	0.01	Max 0.1
Methomyl	<LOQ	mg/kg	0.01	Max 1.0
Metiram	<LOQ	mg/kg	0.01	Max 5.0
Propineb	<LOQ	mg/kg	0.01	Max 1.0
Famoxadone	<LOQ	mg/kg	0.01	Max 2.0
Decamethrin / Deltamethrin	<LOQ	mg/kg	0.01	Max 0.3
Iprodione	<LOQ	mg/kg	0.01	Max 5.0
Metalaxyl-M	<LOQ	mg/kg	0.01	Max 0.5
Phorate (sum of phorate, its oxygen analogue and their sulfones expressed as phorate)	<LOQ	mg/kg	0.01	Max 0.1
Trifloxystrobin	<LOQ	mg/kg	0.01	Max 1.0
Kasugamycin	<LOQ	mg/kg	0.01	Max 0.05
Sodium Para Nitro Phenolate	<LOQ	mg/kg	0.01	Max 0.3
Alpha naphthyl acetic acid	<LOQ	mg/kg	0.01	Max 0.1

Group 1- samples were collected from K.R market, Krishna Rajendra market, Bangalore – 02.
The results of G1 samples reveal that the presence of pesticide residue is below the limit of quantification.
Identical results were revealed from other samples of Group 1.

Table 2: Results of Group 2 and Group 3 market samples of Tomatoes

Test name	Results	Unit	LOQ/LOD
2,4 DDD	<LOQ	mg/kg	0.01
2,4 DDE	<LOQ	mg/kg	0.01
2,4 DDT	<LOQ	mg/kg	0.01
4,4 DDD	<LOQ	mg/kg	0.01
4,4 DDE	<LOQ	mg/kg	0.01
4,4 DDT	<LOQ	mg/kg	0.01
4-Bromo-2-Chlorophenol	<LOQ	mg/kg	0.01
Acephate	<LOQ	mg/kg	0.01
Aldrin	<LOQ	mg/kg	0.01
Anilophos	<LOQ	mg/kg	0.01
Azinphos ethyl	<LOQ	mg/kg	0.01
Captan	<LOQ	mg/kg	0.01
Chlordane-cis	<LOQ	mg/kg	0.01
Chlordane-trans	<LOQ	mg/kg	0.01
Chlofenpyr	<LOQ	mg/kg	0.01
Chloropyrifos Methyl	<LOQ	mg/kg	0.01
Chloropyrifos	<LOQ	mg/kg	0.01
Chlorfenvinphos	<LOQ	mg/kg	0.01
Cis-1,2,3,6-Tetrahydrophthalimide	<LOQ	mg/kg	0.01
Diazinon	<LOQ	mg/kg	0.01
Dichlorvos	<LOQ	mg/kg	0.01
Dicofol	<LOQ	mg/kg	0.01
Dieldrin	<LOQ	mg/kg	0.01
Dimethoate	<LOQ	mg/kg	0.01
Ediphenphos	<LOQ	mg/kg	0.01
Endosulfan Beta	<LOQ	mg/kg	0.01
Endosulfan Alpha	<LOQ	mg/kg	0.01
Endosulfan Sulphate	<LOQ	mg/kg	0.01
Endrin	<LOQ	mg/kg	0.01
Ethion	<LOQ	mg/kg	0.01
Fenamiphos	<LOQ	mg/kg	0.01
Fenchlorphos	<LOQ	mg/kg	0.01
Fenitrothion	<LOQ	mg/kg	0.01
Fensulfothion	<LOQ	mg/kg	0.01
Fenthion	<LOQ	mg/kg	0.01
Fenthion-sulfone	<LOQ	mg/kg	0.01
Fonophos	<LOQ	mg/kg	0.01
Heptachlor	<LOQ	mg/kg	0.01
Heptachlor Epoxide	<LOQ	mg/kg	0.01
Iprobenfos	<LOQ	mg/kg	0.01
Malaxon	<LOQ	mg/kg	0.01
Malathion	<LOQ	mg/kg	0.01
Methidathion	<LOQ	mg/kg	0.01
Methamidophos	<LOQ	mg/kg	0.01
Methaxychlor	<LOQ	mg/kg	0.01
Mirex	<LOQ	mg/kg	0.01
Monocrotophos	<LOQ	mg/kg	0.01
Omethoate	<LOQ	mg/kg	0.01
Parathion-ethyl	<LOQ	mg/kg	0.01
Parathion-methyl	<LOQ	mg/kg	0.01
Paraoxn Methyl	<LOQ	mg/kg	0.01
Phenthoate	<LOQ	mg/kg	0.01
Phorate	<LOQ	mg/kg	0.01
Phorate sulfone	<LOQ	mg/kg	0.01
Phosalone	<LOQ	mg/kg	0.01
Phosmet	<LOQ	mg/kg	0.01
Pirimiphos-ethyl	<LOQ	mg/kg	0.01
Pirimiphos-methyl	<LOQ	mg/kg	0.01
Profenofos	<LOQ	mg/kg	0.01
Quinalphos	<LOQ	mg/kg	0.01
Thiometon-Sulfoxide	<LOQ	mg/kg	0.01
Thiometon-Sulfone	<LOQ	mg/kg	0.01
Thiometon	<LOQ	mg/kg	0.01
Triazophos	<LOQ	mg/kg	0.01
Trichlorfon	<LOQ	mg/kg	0.01
Cadusafos	<LOQ	mg/kg	0.01
Caumaphos	<LOQ	mg/kg	0.01
Phorate- sulfoxide	<LOQ	mg/kg	0.01
Phosphamidon	<LOQ	mg/kg	0.01

Phoxim	<LOQ	mg/kg	0.01
Propetamphos	<LOQ	mg/kg	0.01
Pyrazophos	<LOQ	mg/kg	0.01
Temephos	<LOQ	mg/kg	0.01
Tolclofos-methyl	<LOQ	mg/kg	0.01
Chlorfenson	<LOQ	mg/kg	0.01

Group 2 sample was collected from Yeshwanthpur market, APMC yard, Bangalore- 22
Group 3 sample was collected from Madiwala wholesale market, Bangalore-68
The results of G 2 and G 3 samples reveal that the presence of pesticide residue is below the limit of quantification.

DISCUSSION

The present study aimed to assess the levels of pesticide residues in Tomatoes collected from different markets using various washing methods. The analysis was conducted through rigorous analytical techniques, and the results shed light on Tomatoes consumption's safety regarding pesticide contamination.

Firstly, it's essential to discuss the methodology employed in this study. The samples were collected from various markets and subjected to different washing treatments before analysis. This approach aimed to mimic real-life scenarios where consumers may wash Tomatoes using various methods to reduce pesticide residues. Analytical techniques such as QuECHERS, LCMSMS, and GCMSMS[5,6] were utilised, following standard operating procedures to ensure accuracy and reliability in the results.

The usage of pesticides has increased due to the increased need for food to feed the world's population, which is predicted to reach 8.5 billion by 2030. About 25% of pesticides are used in developing countries, with a notably high concentration of vegetables.

Tomato (*Solanum lycopersicum* Linn.) crop is one of the most popular vegetables in tropical and sub-tropical regions worldwide. Tomato is one of the vegetables which is used regularly in Indian culinary and India is one of the major countries which produces Tomatoes. In Karnataka, the major districts that grow Tomatoes are Kolar, Mandya, Belagavi, Haveri, Davangere, Chikkaballapura, and Bengaluru Rural.

Unlike other vegetables, Tomato is prone to insect pests and diseases due to its tenderness and moisture content compared to other crops. The significant issues that farmers encounter in Tomatoes cultivation are pests and disease control among insect pests, fruit borer, *Helicoverpa armigera*, Leaf miner, *Lriomyza trifolii*, Pinworm, *Tuta absoluta* and Thrips. The common diseases are bacteria wilt, fungal wilt and blight. Tomato growers are aware of the damage caused by these pests and diseases to Tomatoes production, which has led farmers to use pesticides as a major means to control them. Also, it is inevitable to avoid production loss.

Farmers use different types of pesticides, and more than 25 are used in growing Tomatoes. Most farmers cannot identify suitable pesticides and their proper application or alternative measures for managing pests and diseases than exclusively depending only on pesticides.

Despite the established evidence of intensive use of pesticides in Tomatoes farming and presence of pesticide residues in irrigation water, there is limited information on pesticide residues in Tomatoes as well as possible dietary exposure to pesticides from fresh tomatoes.

Long-term low exposure is increasingly linked to human health effects such as immune suppression, hormone disruption, diminished intelligence, reproduction abnormalities and cancer[7]. Various studies in humans and animals support the idea that pesticides induce oxidative stress[8].

In the general population, the residue level measures the incidental exposure and/or average levels of the persistent pesticides, mainly done through the food chain. Residues of OC insecticides, especially DDT and HCH, have been detected in humans and their environments worldwide. However, these very high levels have been reported in human blood, fat and milk samples in India.

The first group of samples given for analysis in this study was the KR market, where all five samples were collected, processed and given for analysis to the lab. As the results revealed that even samples without washing didn't have more residue than MRL, the subsequent two market samples were restricted to single samples, i.e., Tomatoes samples without washing. The result of the study shows the presence of different pesticides in all market samples less than the limit of quantification; that is, no pesticide residue on Tomatoes samples exceeds the MRL; this may be because of the time period it takes to reach the market. When the withdrawal period is maintained, the residue escapes from the samples and enters the environment. Also, the farmers' knowledge regarding judicial usage of pesticides, such as pesticide application practices, adopting IPM, etc., has been reflected in the study results. Though none of the samples shows residues above MRL, low-dose ingestion through food commodities affects the health of humans.

There is a shortage of information on the prevalence of diseases linked to pesticide use among certain populations in developing nations. Monitoring the end outcome of human exposure—pesticide residue levels in bodily fluids and tissues of the general public—can yield important information. Owing to man's many advantages from pesticides, these man-made substances provide the finest option for individuals who balance the risk-benefit ratio. It is estimated that the economic cost of pesticides to non-target species, such as people, is around $8 billion per year in developing nations. Using pesticides is essential for underdeveloped countries because no one wants to experience starvation or contract infectious illnesses. Thus, taking moderate risks may be the best course of action. Commercial motivations should not be the foundation for any decision about pesticides; instead, scientific judgment should.

There are several inherent barriers in thoroughly analysing the hazards to human health due to pesticides, such as age, sex, race, socio-economic position, food, etc, all of which influence human exposure to pesticides.

The simultaneous exposure to additional pesticide contaminants found in food, water, air, medications, and other substances can significantly impact the long-term consequences of low-level pesticide exposure. The ecosystem and non-target creatures, such as beneficial soil microorganisms, insects, plants, fish, and birds, are seriously in danger from pesticide pollution.

Pesticides that persistently accumulate in the human body for several years can be considered as Dushi-visha (Latent poison), and the residue present in food commodities consumed can be regarded as Gara-visha (Artificial poison). Acute poisoning in occupational exposure to pesticides can be correlated with Gara-visha (Artificial poison) and can be managed through its treatment protocol. Also, chronic exposure to pesticides in low doses can accumulate in the body as a cumulative poison and show symptoms similar to Dushi-visha (Latent poison). It can hamper cellular metabolism, leading to cell injury, which causes various clinical manifestations according to saturation and weak immune response, further leading to complications such as irreversible cell damage, Mental illness, Parkinson's disease, Alzheimer's disease, cancer and permanent organ damage [7,9]. Ayurvedic protocol followed for Dushi-visha (Latent poison) and Gara-visha (Artificial poison) treatment can be adopted to prevent and eliminate accumulated cumulative toxicity and manage symptoms through purificatory procedures and medicaments using various agadas (antidotes)[10].

Further research is warranted to explore long-term health effects associated with low-level pesticide exposure and to develop strategies for effectively reducing pesticide residues in food commodities. Additionally, collaborative efforts among stakeholders, including farmers, regulators, and consumers, are essential to address the complex challenges posed by pesticide contamination in the food supply chain.

CONCLUSION

Based on the study's findings, Tomatoes samples from all three markets have pesticide residue present below the limit of quantification or LOQ < 0.1 mg/kg. The long-term effects of low-quantity pesticide exposure through food commodities must be considered, even though the study finds that Tomatoes market samples are safe to eat. Further research can be done to assess long-term low exposure through food commodities on humans that causes cumulative toxicity, even if pesticide residues below MRLs in food are thought to be non-hazardous to humans. The superiority of the Ayurvedic treatment plan lies in its ability to heal cumulative pesticide damage through internal therapy and detoxification.

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