Journal of Nutrition and Food Security
Shahid Sadoughi University of Medical Sciences
School of Public Health
Department of Nutrition
Nutrition & Food Security Research Center

eISSN: 2476-7425 pISSN: 2476-7417 JNFS 2024; 9(1): 132-143 Website: jnfs.ssu.ac.ir

Pesticide Residue in Iranian Fruits and Vegetables: A Systematic Review

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ARTICLE INFO

SYSTEMATIC REVIEW

Article history:
Received: 6 Jul 2022
Revised: 29 Jul 2022
Accepted: 28 Aug 2022

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ABSTRACT

Background: There is a growing concern about the health-threatening effects of pesticide residues in fruits and vegetables worldwide. This study systematically reviewed the published data on pesticide residues in Iranian fruits and vegetables to clarify the gap in this issue. **Method**: The authors systematically searched PubMed, Google Scholar, Scopus, SID, and Iran Medex to find published studies on pesticide residues in Iranian foods without time and language restrictions. The title and abstract of all articles were evaluated after removing duplicate articles (2289 articles) by two independent reviewers. Finally, 24 articles were found that reported pesticide residues in fruits and vegetables. There was a great variation in measurement methods and pesticides reported across studies, which precluded meta-analysis. Therefore, a summary of the included studies was only reported. **Results**: Twenty-four studies reporting pesticide residues in Iranian fruits and vegetables were included. The percentage of Iranian fruits and vegetables contaminated with pesticides exceeding the maximum residue limit (MRL) was less than 10% in most studies. Contaminated samples were collected mainly from cultivated areas such as fields, orchards, or greenhouses. **Conclusion**: Pesticide residues in food have not been systematically reported in Iran. It was found that only limited articles were published by academic societies on this issue. Considering the current scenario, there is an urgent need to facilitate reliable and continuous measurements of toxic residues in Iranian food.

Keywords: *Pesticide; Fruit; Vegetable; Systematic review; Iran*

Introduction

Ffruits and vegetables are the main components of a healthy diet recommended by international guidelines to improve general health and reduce the risk of several diseases (World Health Organization, 2019). Many studies have identified plant food as food rich in various micronutrients and phytochemicals that are essential for health and prevention of common

This paper should be cited as: Toorang F, Sasanfar B, Pouraram H, Eskandari S***. Pesticide Residue in Iranian Fruits and Vegetables: A Systematic Review.*** *Journal of Nutrition and Food Security (JNFS)*, 2024; 9 (1): 132-143.

[DOI: 10.18502/jnfs.v9i1.14847]

diseases, such as cancer and cardiovascular diseases (Mayne *et al.*, 2016).Moreover, replacing animal food with fruits and vegetables can protect our planet (Vaidyanathan, 2021).

There is a growing concern about the health-threatening effects of pesticide residues in fruits and vegetables worldwide. It is clear that pesticides harm the environment and every living being, including humans. Studies have shown that exposure to pesticides may lead to chronic and short-term health problems in humans. The most common short-term side effects are nausea, vomiting, and headache (Kim *et al.*, 2017). Long-term effects that are not easily detected and can be more dangerous include behavioral changes, several cancers, and disruption of the endocrine and reproductive systems (Alavanja *et al.*, 2004, Asghar *et al.*, 2016, Kim *et al.*, 2017).

On the other hand, most farmers and policymakers believe that pesticides are important components in improving the food security of countries and their use is an inevitable factor to meet the global demand for sufficient and affordable food (Popp *et al.*, 2013). Considering these two arguments, some international organizations, including the World Health Organization (WHO), have established a standard protocol for the use of pesticides, and the maximum residue limit (MRL) for pesticides in food, which is expressed in milligrams per kilogram of food, and if a food has a higher limit, it will be considered unhealthy (Herrman, 1993).

Developing countries such as Iran have been accused of excessive use of toxins, which is generally due to the identification of some high levels of residual toxins in export food baskets. This issue can damage their food image all over the world (Donkor *et al.*, 2016). Moreover, the level of pesticide residues in domestic food is likely to be similar to that of exports, which could affect national health (Carvalho, 2006). These problems may be due to the lack of awareness of food producers, including farmers, as well as ineffective national laws and permits (Carvalho, 2006).

Due to the mentioned danger of pesticides for human health and wildlife, the use of pesticides is under continuous monitoring. Although there have been studies on pesticide residues in Iran, there is no comprehensive information about it. Therefore, this study systematically reviewed the published data on pesticide residues in Iranian fruits and vegetables to clarify the gap in this issue.

Materials and Methods

Data sources: PubMed, Google Scholar, Scopus, SID, and Iran Medex were systematically searched to find published studies on pesticide residues in Iranian foods without time and language restrictions. Different search strategies were used in different databases (**Table 1**) using these keywords:

(Pesticide or herbicide or insecticide) and Iran

Study selection: The title and abstract of all articles were evaluated after removing duplicate articles (2289 articles) by two independent reviewers and resolved disagreements through discussion. The title and abstract of the articles found in Google Scholar were read and 26 articles that met the study criteria were entered into the Endnote file. Reference lists of included studies were reviewed to identify articles not captured by the authors' search.

This study aimed to systematically review all the studies that have reported the residual toxins in Iranian food. After reading the abstracts of the articles, the researchers included 30 studies on fruits and vegetables, 10 on fish, 2 on honey, and 27 on other food types. Considering the comprehensiveness of the data related to fruits and vegetables, as well as the Iranian society's fear of agricultural pesticide residues in fruits and vegetables, only the results related to the pesticide residues in fruits and vegetables were reported. After reading the full text of 30 articles on fruits and vegetables, 24 articles met the study criteria. One study related to laboratory-grown vegetables, three studies on standardized methods for measuring toxins, one study on fungal contamination, and one study on phthalate contamination were excluded.

Data extraction: Data from 24 studies related to

[DOI: 10.18502/jnfs.v9i1.14847]

fruits and vegetables were transferred to Excel tables. The data were summarized based on a table prepared by two reviewers, which included data on the type of vegetables or fruits, pesticides identified, first author and year of publication, geographical location, mean concentration, percentage of contaminated samples, and the place of sample collection (farm, market, or garden). There was a great variation in measurement methods and pesticides reported across studies, which precluded meta-analysis. Therefore, the authors only reported summary findings of the included studies.

Results

First, 2464 articles were found from international electronic databases, 205 of which were duplicate articles, and also 30 articles were found from Persian databases. Therefore, the title and abstract of 2289 articles were reviewed to find studies that investigated pesticide residues in Iranian food. Finally, 24 articles were found that reported pesticide residues in fruits and vegetables (24 articles), wheat (1 article), rice (1 article), tea (1 article), sugar (1 article), eggs (1 article), wild duck (1 article), fish (5 articles), and honey (1 article). Since there was limited information on food groups other than fruits and vegetables, this report was limited to fruits and vegetables.

Most studies measured pesticide residues in samples obtained from gardens, greenhouses, and fields (Behbahaninia, 2007, Ganjeizadeh Rohani *et al.*, 2014, Hagian Shahri *et al.*, 2014, Khak *et al.*, 2016, Khaniki *et al.*, 2011, Leili *et al.*, 2016, Pirsaheb *et al.*, 2017, Sobhanardakani *et al.*, 2016). Two studies measured pesticide residues in samples obtained simultaneously from market and cultivated areas (Sobhanardakani *et al.*, 2014, Sobhanardakani *et al.*, 2016). Jahanmard *et al.* examined tomatoes from a salad factory. This was the only study that tested the residue after processing (Jahanmard *et al.*, 2016). Finally, some studies reported residuals in market samples (Akhlaghi *et al.*, 2013, askari *et al.*, 2014, Hadian and Azizi, 2008). The residual level in the cultivation areas was generally higher than the market.

Most of the studies investigated pesticide residues in cucumber and tomato, as 9 studies were conducted on cucumber (Ardakani *et al.*, 2012, Behbahaninia, 2007, Farshad, 2001, Ganjeizadeh Rohani *et al.*, 2014, Hadian *et al.*, 2006, Hagian Shahri *et al.*, 2014, Khaniki *et al.*, 2011, Leili *et al.*, 2016, Shokrzadeh *et al.*, 2013) and 9 studies on tomato (Ardakani *et al.*, 2012, Bayat *et al.*, 2015, Hadian *et al.*, 2006, Hagian Shahri *et al.*, 2014, Jafari *et al.*, 2012, Jahanmard *et al.*, 2016, Khak *et al.*, 2016, Khaniki *et al.*, 2011, Mohammadi and Imani, 2012). Other studied commodities included apples (Akhlaghi *et al.*, 2013, Hagian Shahri *et al.*, 2014, Mina and Maryam, 2012, Pirsaheb *et al.*, 2017), melons (Akhlaghi *et al.*, 2013, Hadian and Azizi, 2008), grapes (Hagian Shahri *et al.*, 2014), mushrooms (Sobhanardakani *et al.*, 2014), zucchini (Sobhanardakani *et al.*, 2016), strawberry (Golepoor *et al.*, 2014) cherry (Akhlaghi *et al.*, 2013, askari *et al.*, 2014), and watermelons (Akhlaghi *et al.*, 2013). In 24 studies, 36 pesticide residues were reported in different commodities. They included abamectin, diazinon, chlorpyrifos, ethion, imidacloprid, cypermethrin, permethrin, indoxacarb, mancozeb, chlorothalonil, iprodione, thiophanate methyl, carbendazim gelsam, pyrethroids, dischlorompatiraphan, tepe, dichloropatyraphan, tepe, dichloropatylate, carben, dischlorofandoparithion, carblo, endosulfan I, endosulfan II, endosulfan sulfate, oxymethon, methyl, dichlorvos, metalaxyl, fenpropathrin, fenpropathrin, malate, fenitrothion, oxymethon methyl, P metrozine, fesalone, and fenvalerate.

Unfortunately, studies mostly reported only pesticide concentrations, and most of them did not report the percentage of commodities that were contaminated above the MRL. In most of the studies reporting the percentage exceeding the MRL, it was less than ten percent of the commodity. However, two studies reported a high percentage of heavily contaminated commodities. Ganjizadeh reported that 53% of Kerman greenhouse cucumbers were contaminated with diazinon more than the MRL, and this percentage was 78.33% for methyl oxymethon (Ganjeizadeh Rohani *et al.*, 2014). Diazinon contamination was reported in all cucumbers and tomato greenhouses of Chaharmahal and Bakhtiari provinces exceeding the MRL (Khaniki *et al.*, 2011). It should be noted that some studies investigated the residues of banned pesticides such as carbamil and fortunately these products were free of those pesticides.

Table 1. Search strategies in different databases.

Database	Searching strategy	Number of found articles	Date of search
Scopus	(Pesticide OR herbicide OR insecticide [title/abstract]) AND Iran (affiliation)	2066	2018 July 8
PubMed	(Pesticide OR herbicide OR insecticide [title/abstract]) AND Iran (affiliation)	389	2018 July 8
Google Scholar	(Pesticide herbicide insecticide)+ Iran	17500	2018 July 8
Sid	Pesticide or herbicide (in Persian)	25	2018 July 8
Iran medex	Pesticide or herbicide (in Persian)	5	2018 July 8

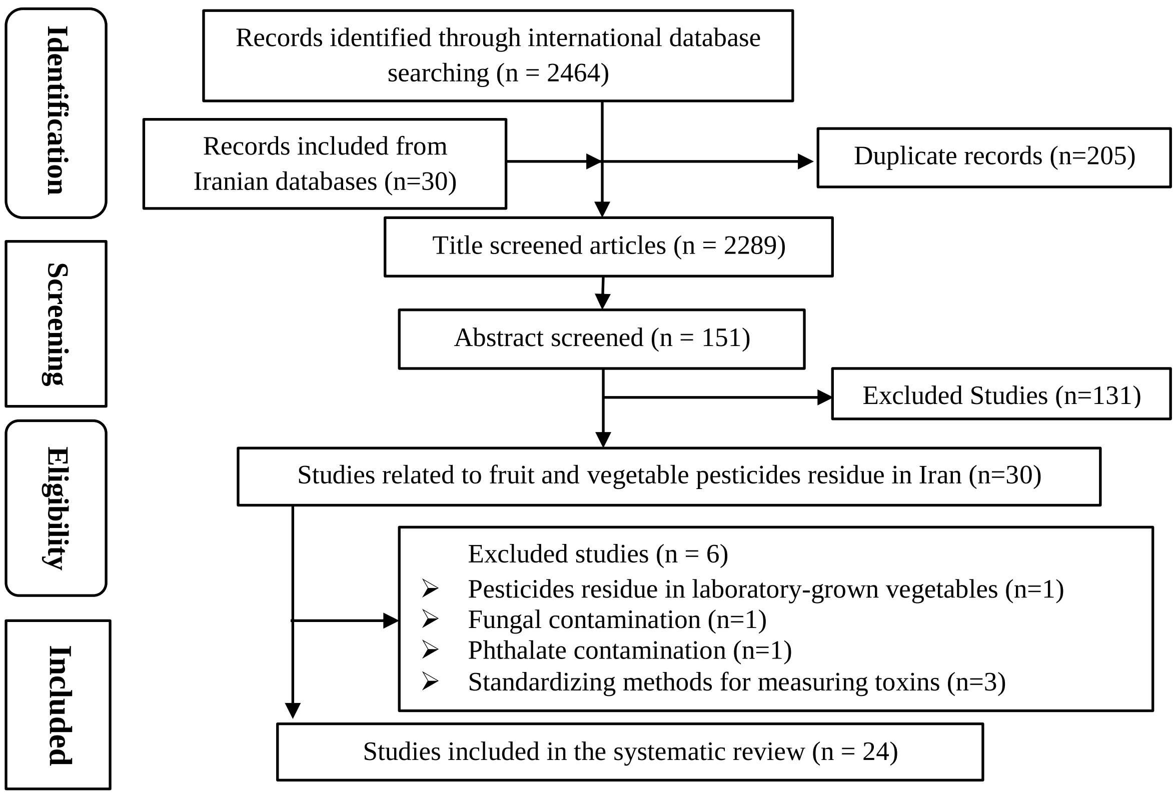

Figure 1. Flow diagram of study screening.

[DOI: 10.18502/jnfs.v9i1.14847]

Table 2. Pesticides detected in fruits and vegetables in Iran.

Author	Sampling site	Sample size	Detecting technique	Geographic location	Commodity	Mean or range of concentrations(ppm) of Detected pesticides
(Pirsaheb *et al.*, 2017)	Gardens	500g of golden or red apples from 50 garden	DLLME-SFO coupled with HPLC-UV	Mahabad	Golden apple	Abamectin (0), Diazinon (10.289), Chlorpyrifos (9.51)
					Red apple	Abamectin (0), Diazinon (8.867), Chlorpyrifos (8.047)
(Leili *et al.*, 2016)	Greenhouses	1000mg from 10 greenhouses	QuEChERS Followed by GC-MS	Hamadan	Cucumber (One day after pesticide application)	Ethion (0.867-0.975), Imidacloprid (1.13-1.207)
(Sobhanardakani *et al.*, 2016)	Greenhouses and markets		Spectrophotometric	Hamadan	Zucchini	Diazinon (0.093-0.159)
(Khak *et al.*, 2016)	Farms	37 samples from every farm		Jam, Dashtestan, Dashti, Deir, and Kangan (mean of all cities are reported)	Tomato	Cypermethrin (0.071±0.069), Permethrin (0.272±0.19), Indoxacarb (0.03±0.017), Mancozeb (0.035±0.019), Chlorothalonil (0.15±0.238), Iprodione (0.004±0.003), Thiophanate Methyl (0.11±0.183), Carbendazim golsam (0.107±0.156), Abamectin (0)
(Jahanmard *et al.*, 2016)	Salad production plant	22 samples	QuEChERS Followed by GC-MS	Isfahan	Tomato	Pyrethroid, Diazinone (107.67-579.81), Chlorpyrifos (144.92-254.84), Primicarb (free), Dischlorvos(free), Carbaryl(free), Malathion(free), Brompropilate (free), Propargit (free), Tetradifone(free), Posalone(free), Iprodion(free), Endosulfane(free)
(Sobhanardakani *et al.*, 2014)	Greenhouses and markets	10 samples	Spectrophotometry	Hamadan	Mushroom	Diazinon (0.04-0.166)
(Hagian Shahri *et al.*, 2014)	Cultivation regions	6 samples of cucumber	QuEChERS Fallowed by GC-MS	Mashhad, Neyshaboor and Sabzevar	Cucumber	Malathion (5.09), Oxydemethon (3.33), Methyl (0.18), Diazinon (0.43), Dichlrovos (2.38), Metalaxyl(0.41), Fenpropathrin(6.32),
		8 samples of tomato		Mashhad, Chenaran, Fariman, Neyshaboor and Ghoochan	Tomato	Fanpropatrin (7.65), Azinphos methyl (0.16), Diazinon (0.235), Phosalone (0.1),
		8samples of cherries		Mashhad and Neyshaboor	Cherry	Diazinon (11.2), Malation (0.79), Fenpropidin (1.57),
		10 samples of grapes		Hagian-shahri M.	Grape	Ethion (2.4), Malathion (12.46), Diazinon (0.48)
		7 samples of apples		Mashhad, Chenaran, Ghoochan and Neyshaboor	Apple	Ethion (1.59), Fenitrothion (0.06)

(Ganjeizadeh Rohani *et al.*, 2014)	Greenhouses	60 samples	spectrophotometry	Kerman	cucumber	Diazinon (0.582), Oxydemeton methyl (1.91)
(Akhlaghi *et al.*, 2013)	Local markets and villages	75	QuEChERS Followed by GC-MS			Diazinon
				A change village	Apple	0.17±0.04
					Grape	0.41±0.15
					Melon	0.27±0.04
					Watermelon	0.12±0.03
					Cherry	0.18±0.04
				Tabas village	Apple	0.25±0.08
					Grape	0.22±0.06
					Melon	0.27±0.06
					Watermelon	0.20±0.06
					Cherry	0.11±0.06
				Barghamad village	Apple	0.14±0.04
					Grape	0.35±0.12
					Melon	0.84±0.19
					Watermelon	0.18±0.06
					Cherry	0.30±0.18
				Sabzevar local market	Apple	0.26±0.11
					Grape	0.30±0.14
					Melon	0.55±0.14
					Watermelon	0.23±0.08
					Cherry	0.88±0.21
				Neyshabur local market	Apple	0.24±0.07
					Grape	0.34±0.15
					Melon	0.26±0.09
					Watermelon	0.17±0.07
					Cherry	0.12±0.02
(Khaniki *et al.*, 2011)	Greenhouses	60 samples	HPLC	Chaharmahal and Bakhtiari province		Oxydimeton methyl
					Cucumber	0.23±0.17
					Tomato	1.61±0.8

[DOI: 10.18502/jnfs.v9i1.14847]

(askari *et al.*, 2014)	Wholesale markets	40 samples		Tehran (From farms in Lavasan, Shahriar, Ghazvin, Mashhad, and Orumieh)	Cherry	Diazinon Mashhad: 0.3Lavasan: 0.29Diazinon in Samples from other cities were undetectable
(Behbahaninia, 2007)	Farms	12 samples	Gas chromatography	Damavand	Cucumber	Tetradifone (0-0.92), Pymetrozine (0.0214-2.67), Deltamethrin (0-0.55)
(Hadian and Azizi, 2006)	Wholesale markets	10 samples of cucumber 10 samples of tomato	GC/ITMS To detect 117 pesticides	Tehran market (from Poldokhtar farms)	Cucumber	Endosulfane I (0.032±0.0049), Endosulfane II (0.03±0.0045), Endosulfane sulphate (0.04±0.0032)
				Tehran market (from Khorramabad farms)	Cucumber	Chlorpyrifos (0.028±0.0037)
				Tehran market (from (Ghazvine farms	Tomato	Phosalone (0.045±0.0084)
				Tehran market (from (Varamin farms	Tomato	Fenvalerate (0.05),
(Golepoor *et al.*, 2014)	Farms	3	QUECHERS GC-MS	Tonekabon	Strawberry	Dursban (ND), Diazinon (ND), Ethion (ND), Malathion (ND)
		120		Bahmanmir-Babolsar		Dursban (3.47±0.52), Diazinon (9.10±1.49), Ethion (1.35±0.06), Malathion (7.99±0.93)
		5		Amol		Dursban (ND), Diazinon (ND), Ethion (ND), Malathion (ND),
		15		Babol		Dursban (8.82±0.82), Diazinon (ND), Ethion (ND), Malathion (ND)
		28		Jooybar		Dursban (9.99 ±1.65), Diazinon (1.84±0.29), Ethion (12.15 ±1.15), Malathion (ND)
		10		Kiakola		Dursban (ND), Diazinon (6.33±1.33), Ethion (6.23±0.23), Malathion (ND)
		10		Behshahr		Dursban(ND), Diazinon(219.68±32.65), Ethion(ND), Malathion (0.56±0.04),
		20		Sari		Ethion (ND), Malathion (ND)
(Mohammadi and Imani, 2012)	Wholesale markets	2000mg in 25 samples from 10 markets	HPLC GC/NPD GC/MS	Karaj	Tomato	Chlorpyrifos (0.2), Deltamethrin (0.09)
(Jafari *et al.*, 2012)	Central fruit and vegetables market	40 greenhouses,40 greenhouse from different cities	HPLC with UV detection	Tehran	Tomato	Dithiocarbamate (0.14)
(Bayat *et al.*, 2015)	The market of Mashhad City	4 samples	HPLC	Hormozgan	Tomato	Diazinon 0.20±0.01
				Khozestan		0.36±0.01

[DOI: 10.18502/jnfs.v9i1.14847]

				Shiraz		0.46±0.01
				Neyshaboor		0.54±0.01
				Chenaran		0.57±0.02
				Mashhad		0.64±0.01
(Mina and Maryam, 2012)	Garden	972 samples		Damavand	Red apple	Diazinon (0.70±0.36), Chlorpyrifos (1.35±0.82),
					Golden apple	Diazinon (0.65±0.17), Chlorpyrifos (1.09±0.21),
(Hadian *et al.*, 2006)	Central fruit and vegetables market in Tehran	10	HPGPC CC/ITMS	Saveh	Cantaloupe	Endosulfan II (0), Endosulfan sulfate (0.06)
		10		Dezful	Watermelon	Endosulfan II (ND), Endosulfan sulfate (ND)
				Ahvaz		Endosulfan II(ND), Endosulfan sulfate (ND)
		10		Varamin	Melon	Endosulfan II(ND), Endosulfan sulfate (ND)
				Torbatejam		Endosulfan II(ND), Endosulfan sulfate (0.02)
(Hadian and Azizi, 2008)	Central fruit and vegetables market in Tehran	10 samples of cucumber	GC/ITMS	Poldokhtar	Cucumber	Endosulfan I (0.032±0.005), Endosulfan II (0.03±0.004)
				Khorramabad		Endosulfan sulphate (0.04±0.003), Chlorpyrifos (0.028±0.004)
		10 samples of tomato		Varamin	Tomato	Phosalone (0.45±0.008) Fenvalerate (0.05)
(Shokrzadeh *et al.*, 2013)	Garden	100	GC/MS	Sari	Orange	Diazinon (0.4)
(Shokerzadeh *et al.*, 2006)	Farm	8 samples	GC	Neka (8 samples)	Cucumber	Benomyl: bush (0.037±0.002), tree (0.043±0.003); Mancozeb: bush (0.029±0.004), tree (0.030±0.03)
		20 samples		Sari (20 samples)		Benomyl: bush (0.21±0.001), tree (0.039±0.003); Mancozeb: bush (0.033±0.002), tree (0.039±0.004)
		16		Jooybar (16 samples)		Benomyl: bush (0.038±0.004), tree (0.041±0.002); Mancozeb: bush (0.046±0.002), tree (0.035±0.003)
		12		Ghaemshahr (12 samples)		Benomyl: bush (0.028±0.003), tree (0.032±0.001); Mancozeb: bush (0.030±0.001), tree (0.021±0.002)
		4		Babol (4 samples)		Benomyl: bush (0.024±0.01), tree (0.042±0.003); Mancozeb: bush (0.031±0.001), tree (0.034±0.004)

		8		Babolsar(8 samples)		Benomyl: bush (0.051±0.004), tree (0.026±0.002); Mancozeb: bush (0.035±0.002), tree (0.048±0.005)
		72		Total (mazandarn province) (72 samples)		Benomyl: bush (0.032±0.002), tree (0.036±0.002); Mancozeb: bush (0.035±0.002), tree (0.036±0.003)
(Ardakani *et al.*, 2012)	Farm	106 samples of cucumber and 48 samples of tomato	GC(ECD/NPD)	Gachsaran	Cucumber	Endosulfan: α isomer (0.352), β isomer (0.443); Diazinon (0.462)
					Tomato	Endosulfan: α isomer (0.325), β isomer (0.284); Diazinon (0.504)
				Kohgyloyeh	Cucumber	Endosulfan: α isomer (0.167), β isomer (0.271); Diazinon (0.205)
					Tomato	Endosulfan: α isomer (0.130), β isomer (0.216); Diazinon (0.195)
				Boyreahmad	Cucumber	Endosulfan: α isomer (0.295), β isomer (0.349); Diazinon (0.669)
					Tomato	Endosulfan: α isomer (0.447), β isomer (0.435); Diazinon (0.392)
				Dena	Cucumber	Endosulfan: α isomer (0.207), β isomer (0.297); Diazinon (0.088)
					Tomato	Endosulfan: α isomer (0.131), β isomer (0.102); Diazinon (0.534)
				Total (kohkiloyeh & boyerahmad province)	Cucumber	Endosulfan: α isomer (0.255), β isomer (0.341); Diazinon (0.355)
					Tomato	Endosulfan: α isomer (0.258), β isomer (0.256); Diazinon (0.406)
	Market	4 samples from each city		Yasouj	Cucumber	Endosulfan: α isomer (Undetectable), β isomer (Undetectable); Diazinon (0.121)
					Tomato	Endosulfan: α isomer (Undetectable), β isomer (0.006); Diazinon (0.030)
				Dehdasht	Cucumber	Endosulfan: α isomer (0.008), β isomer (0.016); Diazinon (0.201)
					Tomato	Endosulfan: α isomer (Undetectable), β isomer (0.011); Diazinon (0.211)
				Ghachsaran	Cucumber	Endosulfan: α isomer (0.021), β isomer (0.031); Diazinon (0.092)
					Tomato	Endosulfan: α isomer (Undetectable), β isomer (Undetectable); Diazinon (Undetectable)
(Farshad, 2001)	Wholesale market	378	GC ECD_TSD	Tehran	Cucumber	B-hch (0.2226±0.042), Linden (0.005±0.0013), Heptachior (0.003±0.0008), Heptachlorepoxid (0.019±0.0122), Dielrin(0.0028±0.0002), PP-DDE(0.004±0.0005), β endosulfan(0.0007±0.0004), OP-DDT(0.02±0.0007), PP-DDT(0.01±0.0215), Parathion(0.0364±0.109), Phamthion (0), Diazinon (0), Malathion (0.136±0.1129), Chloroprimiphos (0), Phirimiphos (0.085±0.0525), Phenirtathion (0.059±0.127)

[DOI: 10.18502/jnfs.v9i1.14847]

Discussion

In this systematic review, 24 studies were included reporting pesticide residues in Iranian fruits and vegetables. The percentage of Iranian fruits and vegetables contaminated with pesticides exceeding the MRL was less than 10% in most studies. Samples of contaminated goods were collected mainly from cultivated areas such as fields, orchards, or greenhouses. The amount of pesticides decreased significantly after a few days; therefore, the residual toxins were less before consumption by people.

Pesticide residues in fruits and vegetables have been reported higher in Ghana (Donkor *et al.*, 2016) compared to Iran. However, the pesticides reported in this study were somewhat different from Iranian studies and the sampling sites were not mentioned. The percentage of foods contaminated with pesticides above the MRL was close to the present study although the pesticides examined were slightly different (Donkor *et al.*, 2016). Overall, pesticide residue control appears to be a serious problem in most developing countries although the extent of the problem can vary slightly. There is now enough evidence to claim misuse or even overuse of pesticides in most developing countries, mostly due to a lack of education (Ecobichon, 2001).

It is generally believed that the use of pesticides is inevitable (Carvalho, 2006) to ensure food security worldwide. On the other hand, the WHO has reported that in developing countries, 37,000 cases of cancer are linked to pesticide use each year (Tudi *et al.*, 2021). In addition, the FAO reported that three million people worldwide are poisoned by pesticides every year, and 200,000 people die each year. The worst part is that the majority of them are from developing countries (Watts, 2010). Another important problem is the use of banned pesticides in developing countries (Tariq *et al.*, 2007). Therefore, it is clear that pesticide residues must be monitored to control side effects.

In fact, pesticide residues in food have not been systematically reported in Iran. Public institutions do not systematically report residues, and only a few articles were published by academic societies. Considering the current scenario, there is an urgent need to facilitate reliable and continuous measurements of toxic residues in Iranian food. What is more important is to create systematic training of farmers to use appropriate pesticides through effective methods such as social marketing. The authors strongly recommend that public awareness of the safe use of pesticides should be raised through mass media and social media. The control of pesticide residues based on the Codex Alimentarius is inevitable for Iran, not only because of the health of citizens but also because of the possibility of exporting food.

Conclusion

This systematic review on pesticide residues in Iran found limited studies, indicating a paucity of data. In most studies, less than 10% of Iranian fruits and vegetables were contaminated with toxins above the acceptable limits. However, at this time, we cannot make an accurate claim about pesticide residues in Iranian food, and further studies are required.

Acknowledgment

There is no acknowledgment.

Authors' contributions

Toorang F designed the study and did the primary search. Toorang F and Sasanfar B performed study selection and data extraction. Eskandari S and Pouraram H consulted the whole study. All authors read and approved the paper.

Conflict of interest

None of the authors declared any conflict of interest.

Funding

None

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[DOI: 10.18502/jnfs.v9i1.14847]