

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

Fatemeh Toorang; PhD 1-3, Bahareh Sasanfar; PhD\* 2,4-6, Hamed Pouraram; PhD 1 & Soheyl Eskandari; PhD 7

<sup>1</sup> Department of Community Nutrition, School of Nutritional Sciences and Dietetics, Tehran University of Medical Sciences, Tehran, Iran; <sup>2</sup> Cancer Research Center, Cancer Institute of Iran, Tehran University of Medical Sciences, Tehran, I.R. Iran; <sup>3</sup> Departments of Medical and Surgical Sciences, University of Bologna, Italy; <sup>4</sup> Department of Nutrition, School of Public Health, Shahid Sadoughi University of Medical Sciences, Yazd, Iran; <sup>5</sup> Research Center for Food Hygiene and Safety, School of Public Health, Shahid Sadoughi University of Medical Sciences, Yazd, Iran; <sup>6</sup> Student Research Committee, Shahid Sadoughi University of Medical Sciences, Yazd, Iran; <sup>7</sup> Food and Drug Laboratory Research Center, Food and Drug Administration, Iran Ministry of Health and Medical Education, Tehran, Iran.

#### ARTICLE INFO

### SYSTEMATIC REVIEW

## Article history:

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

## \*Corresponding author:

bsasanfar@yahoo.com
Department of Community
Nutrition, School of Nutritional
Sciences and Dietetics, Tehran
University of Medical Sciences,
Tehran, Iran.

**Postal code**: 13145-158 **Tel**: +98 21 66581638

#### **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

Figure 1 fruits 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

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 two arguments, some international including the World Health organizations. 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

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

from First, 2464 articles were found 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

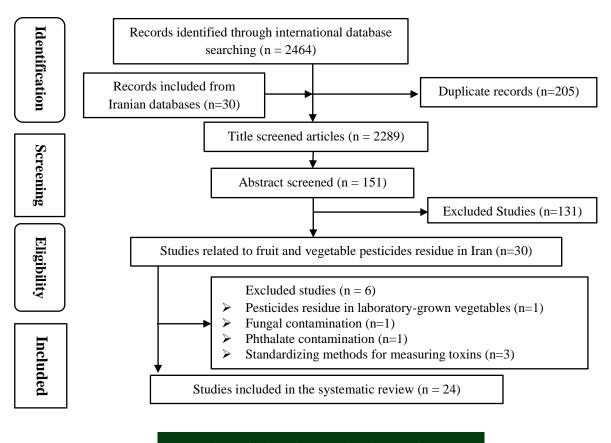


Figure 1. Flow diagram of study screening.

			Table 2. Pe	sticides 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.,	Gardens	500g of golden or red apples	DLLME-SFO coupled with	Mahabad	Golden apple	Abamectin (0), Diazinon (10.289), Chlorpyrifos (9.51)
2017)		from 50 garden	HPLC-UV		Red apple	Abamectin (0), Diazinon (8.867), Chlorpyrifos (8.047)
(Leili <i>et al.</i> , 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 <i>et al.</i> , 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)
		6 samples of cucumber		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),
(Hagian Shahri	Cultivation	8 samples of tomato	QuEChERS	Mashhad, Chenaran, Fariman, Neyshaboor and Ghoochan	Tomato	Fanpropatrin (7.65), Azinphos methyl (0.16), Diazinon (0.235), Phosalone (0.1),
et al., 2014)	regions	8samples of cherries	Fallowed by GC-MS	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)

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

(askari <i>et al.</i> , 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)
				Tehran market (from Poldokhtar farms)	Cucumber	Endosulfane I (0.032±0.0049), Endosulfane II (0.03±0.0045), Endosulfane sulphate (0.04±0.0032)
(Hadian and	Wholesale	10 samples of cucumber	GC/ITMS To detect 117	Tehran market (from Khorramabad farms)	Cucumber	Chlorpyrifos (0.028±0.0037)
Azizi, 2006)	markets	10 samples of tomato	pesticides	Tehran market (from (Ghazvine farms	Tomato	Phosalone (0.045±0.0084)
				Tehran market (from (Varamin farms	Tomato	Fenvalerate (0.05),
		3		Tonekabon		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 15		Amol Babol		Dursban (ND), Diazinon (ND), Ethion (ND), Malathion (ND), Dursban (8.82±0.82), Diazinon (ND), Ethion (ND), Malathion (ND)
(Golepoor et al., 2014)	Farms	28	QUECHERS GC-MS	Jooybar	Strawberry	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 <i>et al.</i> , 2012)	Central fruit and vegetables market	40 greenhouses,40 greenhouse from different cities	HPLC with UV detection	Tehran	Tomato	Dithiocarbamate (0.14)
	The market of	4 samples	HPLC	Hormozgan	Tomato	Diazinon 0.20±0.01
2015)	Mashhad City	1		Khozestan		0.36±0.01

				Shiraz Neyshaboor Chenaran Mashhad		0.46±0.01 0.54±0.01 0.57±0.02 0.64±0.01
(Mina and Maryam, 2012)	Garden	972 samples		Damavand	Red apple  Golden apple	Diazinon (0.70±0.36), Chlorpyrifos (1.35±0.82), Diazinon (0.65±0.17), Chlorpyrifos (1.09±0.21),
		10		Saveh	Cantaloupe	Endosulfan II (0), Endosulfan sulfate (0.06)
	Central fruit	10		Dezful	W	Endosulfan II (ND), Endosulfan sulfate (ND)
(Hadian <i>et al.</i> , 2006)	and vegetables market in	10	HPGPC CC/ITMS	Ahvaz	Watermelon	Endosulfan II(ND), Endosulfan sulfate (ND)
	Tehran	4.0		Varamin	261	Endosulfan II(ND), Endosulfan sulfate (ND)
		10		Torbatejam	Melon	Endosulfan II(ND), Endosulfan sulfate (0.02)
(H. P	Central fruit and	10 samples of		Poldokhtar	Cucumber	Endosulfan I (0.032 $\pm$ 0.005), Endosulfan II (0.03 $\pm$ 0.004)
(Hadian and Azizi, 2008)	vegetables	cucumber	GC/ITMS	Khorramabad		Endosulfan sulphate (0.04±0.003), Chlorpyrifos (0.028±0.004)
	market in Tehran	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)
, ,		8 samples		Neka (8 samples)		Benomyl: bush $(0.037\pm0.002)$ , tree $(0.043\pm0.003)$ ; Mancozeb: bush $(0.029\pm0.004)$ , tree $(0.030\pm0.03)$
(9)		20 samples		Sari (20 samples)		Benomyl: bush $(0.21\pm0.001)$ , tree $(0.039\pm0.003)$ ; Mancozeb: bush $(0.033\pm0.002)$ , tree $(0.039\pm0.004)$
(Shokerzadeh et al., 2006)	Farm	16	GC	Jooybar (16 samples)	Cucumber	Benomyl: bush $(0.038\pm0.004)$ , tree $(0.041\pm0.002)$ ; Mancozeb: bush $(0.046\pm0.002)$ , tree $(0.035\pm0.003)$
,		12		Ghaemshahr (12 samples)		Benomyl: bush $(0.028\pm0.003)$ , tree $(0.032\pm0.001)$ ; Mancozeb: bush $(0.030\pm0.001)$ , tree $(0.021\pm0.002)$
		4		Babol (4 samples)		Benomyl: bush $(0.024\pm0.01)$ , tree $(0.042\pm0.003)$ ; Mancozeb: bush $(0.031\pm0.001)$ , tree $(0.034\pm0.004)$

(0.035±0.002), tree (0.036±0.003)  mber Endosulfan: $\alpha$ isomer (0.352), $\beta$ isomer (0.443); Diazinon (0.462)  to Endosulfan: $\alpha$ isomer (0.325), $\beta$ isomer (0.284); Diazinon (0.504)  mber Endosulfan: $\alpha$ isomer (0.167), $\beta$ isomer (0.271); Diazinon (0.205)  to Endosulfan: $\alpha$ isomer (0.130), $\beta$ isomer (0.216); Diazinon (0.195)  mber Endosulfan: $\alpha$ isomer (0.295), $\beta$ isomer (0.349); Diazinon (0.669)  to Endosulfan: $\alpha$ isomer (0.447), $\beta$ isomer (0.435); Diazinon (0.392)  mber Endosulfan: $\alpha$ isomer (0.207), $\beta$ isomer (0.297); Diazinon (0.088)  to Endosulfan: $\alpha$ isomer (0.131), $\beta$ isomer (0.102); Diazinon (0.534)  mber Endosulfan: $\alpha$ isomer (0.255), $\beta$ isomer (0.341); Diazinon (0.355)
to Endosulfan: $\alpha$ isomer (0.130), $\beta$ isomer (0.216); Diazinon (0.195) mber Endosulfan: $\alpha$ isomer (0.295), $\beta$ isomer (0.349); Diazinon (0.669) to Endosulfan: $\alpha$ isomer (0.447), $\beta$ isomer (0.435); Diazinon (0.392) mber Endosulfan: $\alpha$ isomer (0.207), $\beta$ isomer (0.297); Diazinon (0.088) to Endosulfan: $\alpha$ isomer (0.131), $\beta$ isomer (0.102); Diazinon (0.534) mber Endosulfan: $\alpha$ isomer (0.255), $\beta$ isomer (0.341); Diazinon (0.355)
to Endosulfan: $\alpha$ isomer (0.447), $\beta$ isomer (0.435); Diazinon (0.392) mber Endosulfan: $\alpha$ isomer (0.207), $\beta$ isomer (0.297); Diazinon (0.088) to Endosulfan: $\alpha$ isomer (0.131), $\beta$ isomer (0.102); Diazinon (0.534) mber Endosulfan: $\alpha$ isomer (0.255), $\beta$ isomer (0.341); Diazinon (0.355)
to Endosulfan: $\alpha$ isomer (0.131), $\beta$ isomer (0.102); Diazinon (0.534) mber Endosulfan: $\alpha$ isomer (0.255), $\beta$ isomer (0.341); Diazinon (0.355)
` ''• ` ` ` ''• ` ` ` ''
to Endosulfan: $\alpha$ isomer (0.258), $\beta$ isomer (0.256); Diazinon (0.406)
mber Endosulfan: $\alpha$ isomer (Undetectable), $\beta$ isomer (Undetectable); Diazinon (0.121)
to Endosulfan: $\alpha$ isomer (Undetectable), $\beta$ isomer (0.006); Diazinon (0.030)
mber Endosulfan: $\alpha$ isomer (0.008), $\beta$ isomer (0.016); Diazinon (0.201)
to Endosulfan: $\alpha$ isomer (Undetectable), $\beta$ isomer (0.011); Diazinon (0.211)
mber Endosulfan: $\alpha$ isomer (0.021), $\beta$ isomer (0.031); Diazinon (0.092)
to Endosulfan: α isomer (Undetectable), β isomer (Undetectable); Diazinon (Undetectable)
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-
1

#### **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 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

### References

Akhlaghi H, Motavalizadehkakhky A & Emamiyan R 2013. Determination of diazinon in fruits from northeast of Iran using the QuEChERS sample preparation method and GC/MS. Asian journal of chemistry. 25 (3): 1727.

- Alavanja MC, Hoppin JA & Kamel F 2004. Health effects of chronic pesticide exposure: cancer and neurotoxicity. *Annual review of public health.* **25**: 155.
- Ardakani AS, morovati m & entesari m 2012. Residue of endosulfan and diazinon pesticides in tomato and green cucumber fields in Kohgilouye and Boyer Ahmad provinces. *Journal of genetic engineering and biosafety.* **1** (2).
- **Asghar U, Malik M & Javed A** 2016. Pesticide exposure and human health: a review. *Journal of ecosystem & ecography open access.* 5: 2.
- askari m, morowati m & eimani s 2014. Determination of Diazinon residue levels on Cherry, Cerasus avium supplied to Tehran central fruit and vegetable market. *Genetic engineering and biosafety journal.* 2 (2): 119-126.
- **Bayat M, Hassanzadeh-Khayyat M & Mohajeri SA** 2015. Determination of diazinon pesticide residue in tomato fruit and tomato paste by molecularly imprinted solid-phase extraction coupled with liquid chromatography analysis. *Food analytical methods.* **8 (4)**: 1034-1041.
- **Behbahaninia** 2007. Chemical contamination of cucumber product with the chemical poisons pmetrozine, deltamethrin, and tetradifon in Damavand region. *Journal of plant and ecosystem.* **2 (8)**: 118-128.
- **Carvalho FP** 2006. Agriculture, pesticides, food security and food safety. *Environmental science* & *policy*. **9** (7-8): 685-692.
- **Donkor A, et al.** 2016. Pesticide residues in fruits and vegetables in Ghana: a review. *Environmental science and pollution research.* **23** (19): 18966-18987.
- **Ecobichon DJ** 2001. Pesticide use in developing countries. *Toxicology*. **160** (**1-3**): 27-33.
- **Farshad A** 2001. Evaluation of Chlorine and Phosphorus Pesticide Residual in Cucumber in Tehran Fruit and Vegtable Center Market and Its Health Hazards Effects. *Internal medicine today*. **6** (**14**): 50-59.
- Ganjeizadeh Rohani F, Mahdavi V & Aminaei MM 2014. Investigation on diazinon and oxydemeton-methyl residues in cucumbers

- grown in Kerman greenhouses. *Environmental monitoring and assessment.* **186** (7): 3995-3999.
- Golepoor M, et al. 2014. Assessment of Organophosphorus Residues together in Strawberry Produced in Mazandaran, Iran. *Journal of Mazandaran University of Medical Sciences.* 23 (109): 93-102.
- Hadian Z & Azizi M 2006. Pesticide Residues In Vegetables Marketed In The Main Wholesale Fruit And Vegetable Market In Tehran As Determined By Gas Chromatography/Mass Spectrometry, 2005. *Journal of nutrition sciences & food technology*. 1 (2): 13-20.
- **Hadian Z & Azizi mh** 2008. Evaluation of the residual amount of pesticides by gas chromatography-mass spectrometry method in some vegetables offered in the main fruit and vegetable square of Tehran 2014. *Iranian journal of nutrition sciences & food technology.* **1** (2): 13-20.
- Hadian Z, Azzi MH & Ferdousi R 2006. Determination of chlorinated pesticide residues in vegetables by gas chromatography/mass spectrometry. *Journal of food science and technology*. **3 (8)**: 67-74.
- Hagian Shahri M, Sonei A, Zohour E, Khoshbazm R & Tagbakhsh MR 2014. Investigation on residue of pesticides in some horticultural crops with gas chromatography method (GC/MS) in Khorassan Razavi Province. *Journal of applied research in plant protection.* 3 (2): 93-106.
- **Herrman J1** 1993. The role of the World Health Organization in the evaluation of pesticides. *Regulatory toxicology and pharmacology.* **17** (3): 282-286.
- **Jafari A, et al.** 2012. Monitoring dithiocarbamate fungicide residues in greenhouse and nongreenhouse tomatoes in Iran by HPLC-UV. *Food additives & contaminants: Part B.* **5** (2): 87-92.
- Jahanmard E, Ansari F & Feizi M 2016. Evaluation of Quechers sample preparation and GC mass spectrometry method for the determination of 15 pesticide residues in tomatoes used in salad production plants. *Iranian journal of public health.* 45 (2): 230.

- **Khak MT, et al.** 2016. Determining the residual cypermethrin, permethrin, indoxacarb and mancozeb in tomato produced in bushehr province farms. *International journal of medical research & health sciences.* **5** (5): 210-217.
- Khaniki J, Fadaei A, Sadeghi M & Mardani G 2011. Study of Oxydimeton methyl residues in cucumber & tomato grown in some of greenhouses of Chaharmahal va Bachtiari province by HPLC method. *Journal of Shahrekord Uuniversity of Medical Sciences.* 13 (4): 9-17.
- **Kim K-H, Kabir E & Jahan SA** 2017. Exposure to pesticides and the associated human health effects. *Science of the total environment*. **575**: 525-535.
- **Leili M, et al.** 2016. Determination of pesticides residues in cucumbers grown in greenhouse and the effect of some procedures on their residues. *Iranian journal of public health.* **45** (**11**): 1481.
- Mayne ST, Playdon MC & Rock CL 2016. Diet, nutrition, and cancer: past, present and future. *Nature reviews clinical oncology.* **13** (**8**): 504-515.
- **Mina M & Maryam F** 2012. Determining the residual amount of diazinon and chlorpyrifos in Golden and Red apple varieties of the region. *Ecology* **38** (**62**): 111-116.
- **Mohammadi S & Imani S** 2012. Deltamethrin and chloropyrifos residue determination on greenhouse tomato in Karaj by Solid Phase Extraction. *Plant protection journal.* **4 (1)**.
- Pirsaheb M, Fattahi N, Rahimi R, Sharafi K & Ghaffari HR 2017. Evaluation of abamectin, diazinon and chlorpyrifos pesticide residues in apple product of Mahabad region gardens: Iran in 2014. *Food chemistry.* 231: 148-155.
- Popp J, Pető K & Nagy J 2013. Pesticide productivity and food security. A review. Agronomy for sustainable development. 33 (1):

243-255.

- Shokerzadeh M, Vahedi H & Shabankhani B 2006. Investigation and Measurement of Pesticidal Residues Benomil and Mancazeb in Cucumber Produced in Mazandaran. *Journal of Shahid Sadoughi University of Medical Sciences*. 13 (5): 59-64.
- **Shokrzadeh M, Karami M, Jafari Valoujaei M**& Zamani Renani A 2013. Measuring Diazinon residue in Thampson orange. *Journal of Mazandaran University of Medical Sciences.* 23 (105): 91-99.
- **Sobhanardakani S, Sadri S & Jameh Bozorgi S** 2014. Evaluation of organophosphorus pesticide diazinon residue in greenhouse crops using spectrophotometry (case study: mushroom). *Food hygiene.* **3 (4 (12))**: 73-80.
- Sobhanardakani S, Younesian M & Jameh Bozorgi S 2016. Evaluation of organophosphorus pesticide diazinon residues in greenhouse crops (Case study: Zucchini). *Journal of environmental science and technology.* **18** (3): 141-148.
- Tariq MI, Afzal S, Hussain I & Sultana N 2007. Pesticides exposure in Pakistan: a review. *Environment international.* 33 (8): 1107-1122.
- **Tudi M, et al.** 2021. Agriculture development, pesticide application and its impact on the environment. *International journal of environmental research and public health.* **18** (3): 1112.
- Vaidyanathan G 2021. What humanity should eat to stay healthy and save the planet. *Nature*. **600** (7887): 22-25.
- Watts M 2010. Pesticides: Sowing poison, growing hunger, reaping sorrow. Pesticide Action Network Asia and the Pacific.
- World Health Organization 2019. Healthy diet. World Health Organization. Regional Office for the Eastern Mediterranean.