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A Review of Pesticide Residues in Agricultural and Food Products of Iran

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ABSTRACT

Introduction: Pest control strategies are essential to reducing food waste and providing fresh, safe food products. However, the excessive and uncontrolled use of pesticides have caused severe environmental and health problems. The present study aimed to evaluate the level of pesticide residues in food products in Iran through reviewing the current literature.
Methods: A comprehensive literature review was conducted via searching in databases such as PubMed, Google Scholar, ScienceDirect, and SID to identify the abstracts and titles of the relevant papers using English and Persian keywords, including 'pesticide residues', 'Iran', and 'food' or their Persian equivalents.
Results: Several studies have investigated the level of pesticide contamination in various food materials in Iran, the majority of which have been focused on the foods of vegetal origin (e.g., cucumbers, tomatoes, and melons). Various pesticides, including organophosphorus, pyrethroids and organochlorines, were assessed in these studies, and organochlorines were the main tested pesticides in foods of animal origin. According to the review, illegal levels of pesticides are still detected in foods of vegetal and animal origin in some areas of the country.
Conclusion: Although pesticide residues in food materials are an important health issue, it seems that the national efforts to determine the level of these substances in foodstuffs are inadequate. Therefore, national food safety authorities and researchers must pay special attention to improving the current status of pesticide use in food products.

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Introduction

In response to the growing human population, food producers must secure food supplies by expanding the production and minimizing food waste. Agricultural products, such as fruits and vegetables, constitute a major part of human diet. These products are normally at the risk of various deteriorating agents, such as insects, bacteria, and fungi.

A substantial portion of food products could be destroyed or eliminated by pests. Therefore, pest control strategies are essential to reducing food waste and providing fresh, safe food products. In addition to foods of vegetal origin, animal-based foodstuffs may also be targeted by different types of pests. In such an event, numerous pesticides (e.g., fungicides and insecticides) are extensively applied for crops and in the food industry for the protection of foods and fiber (1). Statistics suggest that lack of pesticide use leads to the loss of one-third of crops in agriculture (2). These compounds are also used in other sections, such as urban life, for comfort. However, their excessive and uncontrolled applications may cause severe environmental and health problems due to their toxic nature, bioaccumulation properties, volatility, and long half-lives in the environment and tissues (3).

Despite the importance of pesticide contamination in food products, there have been

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insufficient efforts to determine the level of these toxic materials in foodstuffs in Iran. The present study aimed to evaluate the pesticides in foods based on the method of detection and residual level in various food products in Iran through exploring the current literature in this regard.

Material and methods

A comprehensive literature review was conducted via searching in databases such as PubMed, Google Scholar, ScienceDirect, and SID to identify the abstracts and titles of the relevant papers using English and Persian keywords, including 'pesticide residues', 'Iran', and 'food' or their Persian equivalents. In total, 11 articles were identified, and the retrieved data have been discussed in the following section.

Results and Discussion

Pesticides

Pesticides are mixtures or substances designated for limiting and destroying various types of pests. Predominantly, pesticides are classified into two main categories of chemical pesticides and biopesticides. Biopesticides are derived from natural sources, such as plants, animals, and bacteria, while chemical pesticides are basically synthetic (3). Chemical pesticides are found in five classes of bioactive agents, including herbicides, fungicides, insecticides, rodenticides, and nematicides (4, 5). Multiple sectors are involved in pesticide use, including agriculture, horticulture, livestock farming, homes, and industries. However, these materials are mainly used in the agricultural sector and may ultimately be found in the final food products.

Pesticides are classified into four main categories, including organophosphorus, organochlorines, carbamates, and pyrethroids. Organophosphates are currently the most favored family of pesticides in the market, which are widely used across the world. Several known pesticides belong to this family, such as chlorpyrifos, diazinon, malathion, and phosmet (6).

Organophosphates are degradable, lipophilic compounds due their ester form and are used as insecticides, herbicides, and fungicides. Carbamates are another degradable pesticide that are mainly applied for pest control in the agriculture and household sectors (7). Due to the high toxicity, bioaccumulation properties, and other side-effects of organochlorines (e.g., carcinogenic and estrogenic effects), as well as their resistance to degradation in the environment, many countries have banned the use of this class of pesticides (8). Moreover, organophosphorus and carbamates are comparatively more cost-efficient and have wider applications since they act against a broad spectrum of pests. Furthermore, they are more available compared to organochlorines. Carbamates and organophosphorus have the same action site, where the acetylcholinesterase enzyme in the central nervous system (CNS) is inhibited by these materials, resulting in CNS malfunction. Pyrethroids are another class of degradable pesticides that are commonly applied for household pests and crops. Unlike organophosphorus and carbamates, pyrethroids disrupt the normal function of voltage-gated sodium ion channel in the neuronal membrane.

In Iran, various pesticides are used in agriculture and other sectors, which mostly belong to the aforementioned families of pesticides. Previous studies focusing on the foodstuffs produced in Iran have reported contamination with several organophosphorus (e.g., dichlorvos, diazinon, chlorpyrifos, and malathion), carbamates (e.g., carbaryl and pirimicarb), and pyrethroids (e.g., fenvalerate) (9-12).

Methods of Pesticide Use

Several methods have been proposed to measure pesticide residues in food products, which are commonly applied by food analysts. To date, conventional techniques such as liquid and gas chromatography, enzyme-linked immunosorbent assay, high-performance liquid chromatography, and capillary electrophoresis have been exploited for pesticide analysis (3).

Although the mentioned methods have acceptable selectivity and sensitivity, there are some limitations in their application, such as complexity, need for highly skilled labor, and costly instruments, which have motivated researchers to consider new analytical approaches in this regard. The alternative advanced methods to the conventional techniques of pesticide residue measurement involve the use of sensors, such as electrochemical biosensors, optical biosensors, piezoelectric biosensors, and molecular imprinted polymer biosensors. These modern techniques have been reported to be rapid, cost-efficient, simple, and highly efficient (6). Furthermore, the detection limits of sensor-based methods are than that of conventional approaches (7).

Pesticide Residues in Different Food Materials in Iran

To date, several studies have investigated the level of pesticide contamination in different food materials in Iran. The majority of these studies have used gas chromatography mass spectrophotometry (GC-MS) for the detection of contaminants. In order for a comprehensive review of the studies conducted regarding pesticide residues in foods in Iran, we classified the food products into two categories of foods of vegetal origin and foods of animal origin.

Foods of Vegetal Origin

The pesticides most commonly found in the food products of vegetal origin are those that are intentionally applied to attack plant diseases (e.g., fungicides) and invertebrate pests (e.g., insecticides and acaricides). Table 1 presented the efforts made to measure pesticide residues

Table 1. Pesticide Residues in Food Products in Different Regions of Iran

Matrix	N	Method of Analysis	Contamination Rate(%)	Pesticide	Type of Pesticide	Contamination Range (or mean) (ppb)	City	Reference
Vegetal Origin								
Wheat Flour	40	GC-MS	10	Malathion	Organophosphate	50.96-62.08	Tehran	(13)
			5	2, 4-DDE	Organochlorine	19.88-15.24		
Black Tea	53	GC-MS	28.3	Bifenthrin	Pyrethroid	17-35	Tehran	(14)
			28.3	Endosulfan sulfate	Organochlorine	7-20		
Cucumbers	60	GC-MS	41.27	Fenpropathrin	Pyrethroid	40.3	Tehran	(11)
				Chlorpryfos	Organophosphate	66.4-148.2		
				Metalaxyl	Acylalanin	40-87.6		
Tomatoes	3	Gas Chromatography/ Flame photometric Detection (GC–FPD)	33	Diazinon	Organophosphate	34.3	Ardabil	(22)
			33	Malathion	Organophosphate	28.9		
Melons	75	GC-MS	8	Dimethoate	Organophosphate	30	Tehran	(16)
				Metalaxyl	Acylalanin	15		
				Permethrin	Pyrethroid	8		
Carrots	25	GC-ITMS	80	Trifluralin	Pyrethroid	70-100	Tehran	(15)
Tomatoes	25		80	Permethrin	Pyrethroid	80-200		
				Chlorpyrifos	Organophosphate	10-60		
Cucumbers	25		-	Iprodione	Organophosphate	20		
Animal Origin								
Cow Milk	35	HPLC	80	Lindne	Organochlorine	0-42	Ahvaz	(17)
			51	Aldrine	Organochlorine	0-40		
Meat (loin)	54	-	-	Lindane	Organochlorine	6-270	Tehran	(19)
			-	DDT	Organochlorine	6.13		
Heart	21		-	Lindane	Organochlorine	85-450		
				DDT	Organochlorine	5-10		
Duck Muscles	15	GC-MS	-	DDT	Organochlorine	0-7.5	Fereydo on-kenar	(20)
			-	PCB	Organochlorine	20.5-65.5		
Duck Liver	15		-	DDT	Organochlorine	8.5-28		
				PCB	Organochlorine	11-58		
Fish Samples	95	GC-MS	37	DDT	Organochlorine	43-1590	Shadegan Marshes	(21)
			37	PCB	Organochlorine	24-1060		
Cream	40	GC-MS	-	Aldrine	Organochlorine	0.116	Tabriz	(18)
				DDT	Organochlorine	0.83		
Cheese	40		-	Aldrine	Organochlorine	0.53		
				DDT	Organochlorine	0.14		
Butter	40		-	Aldrine	Organochlorine	-		
				DDT	Organochlorine	-		
Milk	40		-	Aldrine	Organochlorine	1.4		
				DDT	Organochlorine	1.44		

in different food products of vegetal and animal origin in Iran.

The amount of the pesticides on crops and foods are restricted in many countries, including Iran, in order to guaranty the safety of food products. The maximum residue levels (MRL) of pesticides in various foods have been established based on the observed toxic effects of these materials, proper agricultural practices, and consumption of the food product. In general, the standard range of MRLs has been set at 10-10,000 ppb by the European Union (EU) for various food products (2). Accordingly, the Institute of Standards and Industrial Research of Iran has also published a list of MRLs for different pesticides in various foods (10).

As can be seen in Table 1, the residues of some known pesticides have been evaluated in different vegetal foods, including cucumbers, tomatoes, and melon. In a study, Rezaei et al. (2017) reported that only four out of 40 wheat flour samples were contaminated with malathion and 2, 4-DDE, and the contamination levels were below the national limits (13). On the other hand, examination of the residues of 25 pesticides of black tea in the local markets of Tehran (Iran) revealed that 28.3% of the samples were contaminated, while all the positive tea samples contained unregistered and unregulated pesticides (e.g., bifenthrin or endosulfan sulfate)(14). However, the pesticide levels were below the standard limits of the EU in all the tested samples in our research.

Cucurbits are a major plant family, consisting of numerous food products of vegetal origin, such as cucumbers, tomatoes, and melons. The safety of these products has been widely investigated in Iran, particularly in terms of pesticide residues. In two different studies, the contamination of cucumbers with various types of organophosphates and pyrethroid pesticides were assessed (11, 15). In another research in this regard, Nasiri et al. (2016) stated that among 60 cucumber samples, approximately 42% contained pesticides, while 10% of the total samples had pesticide residues of higher than the maximum acceptable limit. In a study by Hadian et al. (2009), the mean iprodione residue in contaminated cucumbers was estimated at 20 ppb, which did not pass the safety limit (15). Furthermore, the findings of the mentioned study indicated that although some pesticide residues (e.g., trifluralin, permethrin, and chlorpyrifos) were found in the matrix of the tested tomatoes, carrots, and cucumbers, no damages were reported in the consumers.

Despite the perturbing news regarding pesticide residues in food products (e.g., melons) in Iran, the findings of Shoeibi et al. (2017) denoted that the levels of some tested pesticides (e.g., pirimicarb, dimethoate, metalaxyl, alpha-endosulfan and permethrin) were below the limits set by the US Food and Drug Administration (FDA) and the Codex (16).

Foods of Animal Origin

The aim of pesticide use in animal food industries is to control pest population and reduce or prevent pest damages in animals. Consequently, fresh or processed animal-based food products may contain some level of pesticides if contaminated feed or water is used for animals, in the case of the practices involving pesticides in animal husbandries (e.g., beehives and stables) or in food-processing plants. Compared to the studies regarding pesticide residues in vegetal foods, the pesticide contents of animal food products have been rarely investigated in Iran. In this regard, various types of food products have been evaluated, and organochlorines have been reported as the main tested category of pesticides.

Pesticide residues in milk and dairy products have been investigated in several studies in different regions in Iran (17, 18). For instance, Ashnagar et al. (2009) assessed the residues of seven organochlorine insecticides in cow milk samples. According to the findings of the mentioned study, the levels of lindane and DDT were 42 and 280 ppb, respectively, which were above the standards recommended by FAO and WHO. In another research in Tabriz (Iran), evaluation of the pesticide residues in milk and dairy products indicated significantly lower levels of contamination with organochlorines (e..g, aldrin, dieldrin, and DDT) compared to the findings of Ashnagar et al. (18).

In addition to dairy products, muscle tissues and other edible organs of some animal species have also been studied by some researchers in Iran in order to determine the degree of pesticide contamination. In a comprehensive study, the chlorinated pesticide residues in different samples obtained from the carcasses of sheep, cattle, goats, and camels in various regions in Iran were analyzed (19). Based on the degree of organochlorine contamination, the lowest and highest quality was reported in the samples collected from camels and sheep, respectively. However, the concentration of DDT did not pass the WHO maximum limit for meat and fat.

The residues of some important organochlorines have also been evaluated in the wildlife of Iran. In a study in this regard, samples collected from several wild duck species in Fereydoon Kenar wildlife refuge were examined in terms of organochlorine pesticides (20). According to the findings, organochlorines and polychlorinated biphenyls (PCBs), which are persistent pesticides, were more abundant in the muscle tissues compared to the liver. Furthermore, the concentrations of organochlorine pesticides and PCBs have been measured by Davodi et al. (2011) in eight fish species in Shadegan Marshes, which is the largest wetland in Iran (21). In general, organochlorine pesticides (e.g., DDTs) were the most frequent substance in the common carp, while the common barbel had the highest level of hexachlorocyclohexane. However, it was reported that the concentrations of several organochlorines exceeded the standard limits for food safety as proposed by FDA and EU.

Conclusion

Although the pesticide residues in food materials are a crucial health issue, it seems that the national efforts to measure these substances in different foodstuffs are inadequate. With respect to the pesticide residues in the foods of vegetal origin, it seems that carrots and tomatoes are the best food products, whereas black tea and melons are the least optimal products in this regard. Moreover, among animal-based food products, fish samples and dairy products have been reported to contain the highest and lowest levels of pesticides, respectively. According to the current review, illegal levels of pesticides are still found in some foods of vegetal and animal origin in various regions in Iran. Therefore, national food safety authorities and researchers must pay special attention to improving the current status of using pesticides in food production.

Conflict of interest

The authors have no conflicts of interest.

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