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Monitoring and risk assessment of pesticide residues in tomatoes and cucumbers traded in Fayoum governorate markets, Egypt

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رصد وتقييم مخاطر متبقيات المبيدات فى الطماطم والخيار المتداول فى اسواق محافظة الفيوم، مصر

ABSTRACT

Tomato and cucumber are considered the most economically important vegetables in the world and are commonly consumed as fresh or raw. Pesticide residues in these vegetables pose health risks for humans. In this study, we detected 19 pesticides in a total of 36 samples of tomatoes and cucumbers from local markets in Egypt's Fayoum governorate using QuEChERS kits for sample extraction and clean-up, followed by gas chromatography-mass spectrometry (GC-MS). Fifteen and fourteen pesticide residues were detected in tomatoes and cucumbers, respectively, in the collected samples from Fayoum markets with concentrations above the maximum residue limits (MRL). A few pesticide residues were below the detection limit in samples from Itsa and Abshway markets. Moreover, the potential health risks for detected pesticides were assessed using the health risk index. Ethoprophos, chlorfenvinphos, terbufos, and atrazine showed the highest health risk index values in most samples. Thus, this study concluded the importance of continuous monitoring and adequate supervision at local vegetable markets.

Keywords: Assessment risks, Cucumbers, GC/MS analysis, Pesticide Residues, Tomatoes

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1. INTRODUCTION

In recent years, food safety from chemical contamination has been one of the major challenges. Therefore, it is vital to monitor and detect pesticide residues in food products **(Mutengwe *et al.*, 2016; Khoshnam *et al.*, 2022)**. Vegetable consumption has increased with population growth and people's awareness of the health benefits of vegetables. This has prompted farmers to frequently use pesticides to protect the vegetable crop from pests causing huge crop losses and increasing productivity **(Abd-Elhaleem, 2020)**. Tomatoes, *Solanum lycopersicum* L. (Solanceae), and cucumbers, *Cucumis sativus* L. (Cucurbitaceae), are considered the most important economically valuable vegetable crops in the world due to their high health advantages **(Eltohamy *et al.*, 2024)**. Tomato is extremely rich in nutrients as they contain vitamins A and C as well as calcium, iron and potassium. It also a good source of ascorbic acid and lycopene, a potent antioxidant **(Kheyrodin and Kheyrodin, 2017; Ahmed *et al.*, 2024).** Cucumber is rich in nutrients, and can help regulate blood sugar levels, maintain blood pressure, and soothe the skin. They are low in calories, fat, salt, and cholesterol and has a very pleasant taste. **(Xu *et al*., 2024).**

Egypt is an important producer and exporter of cucumber and tomato fruits **(Jiang *et al.*, 2021)**, with production of around 484424.68 tons of cucumber and 6275443.91 tons of tomato from harvested areas of 20403 and 143618 hectares, respectively **(FAOSTAT, 2022).** Both crops are commonly consumed as fresh or raw in salad. Usually in local markets, fresh vegetables are not checked for pesticide residues to the same extent as exported vegetables **(Mutengwe *et al*., 2016).** In this regard, **Singh *et al.*, 2018; Jiang *et al*., (2021)** reported that consuming vegetables may contain pesticide residues, posing a high risk to human health. Pesticide residues can accumulate in the body, causing poisoning, allergies, diarrhea, and cancer. Mass spectroscopy, gas chromatography, high-performance liquid chromatography, and fluorescence detection methods provide accurate and efficient pesticide residue detection, ensuring the safety and quality of food for customers. Furthermore, current technological improvements have enhanced the sensitivity of these techniques **(Dömötörová and Matisová, 2008; Sivaperumal *et al*., 2015; Xu *et al*., 2017; Sun *et al*., 2024; Xu *et al*., 2024)**.

The maximum residue limits (MRLs) in crops, defined by the Codex Alimentarius Commission and the European Union Commission (EU) should be within legally allowed levels, thus protecting consumers health **(FAO and WHO, 2022)**. However, several studies have revealed pesticide residue levels above those established in legal requirements. **Mutengwe *et al*. (2016)** showed that tomato samples collected from the Joburg and Tshwane fresh produce Markets, which are the largest markets in Africa, contained a concentration of boscalid residues (Carboxamide group) higher than the maximum residue limit. In different Egyptian markets, several pesticides (chlorfenapyr, chlorpyrifos, lambda-cyhalothrin, dimethoate bifenazate, fluopyram and captan) were found in tomato samples above the maximum residue limits. While in cucumber, abamectin, acetamiprid, captan, and benconazole were found at values over the maximum residue limit, according to the European Union (EU-MRLs) **(Abuo El-kasem *et al.*, 2023).** In this work, we focused on monitoring and determining pesticide residue levels in tomato and cucumber fruits in Fayoum Governorate markets using gas chromatography-mass spectrometry (GC/MS). Pesticide residue levels were also determined in regard to the maximum residue limits (MRLs) according to EU-Codex. Additionally, an assessment of potential health risk to consumers was conducted. This study aimed to: 1) monitor and determine the pesticide residues from tomato and cucumber fruits collected from retailers' markets in Fayoum governorate at the beginning of summer, 2024); 2) assessment of the health risks of detected compounds on consumers.

2. MATERIALS AND METHODS

2.1. Chemicals used

All chemicals utilized were analytical grade. Nineteen reference standards of pesticide for detection in residue pesticides were obtained from Dr. Ehrenstofer GmbH, Germany; acetonitrile (HPLC grade) was purchased from Fisher Chemicals UK; and QuEChERS extraction kit were purchased from Supelco, USA.

2.2. Sample collection

We collected a total of 36 samples, including 18, fresh, undamaged tomato and cucumber fruits per plant from several local markets in Egypt's Fayoum governorate. Three samples were collected from each of the governorate's six Administrative Centers (Fayoum, Senoras, Ebshway, Youssef Al-Siddiq, Tamiya, and Itsa). The samples were placed in bags and transferred immediately to Fayoum University's Environmental and Food Pollutants Analysis Laboratory for pesticide residue analysis and confirmation of compliance with maximum residual limits.

2.3 Samples preparation and extraction

The multi residual analysis of pesticides was conducted by the Environmental and Food Pollutants Analysis Laboratory (EFPAL) at the Faculty of Agriculture, Fayoum University. A kilogram of each sample (tomato and cucumber) was carefully cleaned with water before being chopped and crushed using a laboratory stainless-steel blender (Waring Commercial, USA). Ten grams from the crushed sample were extracted and cleaned up using the Quick Easy Cheap Effective Rugged Safe (QuEChERS, Supelco, USA) Kits according to standard method DIN EN 15662:2009-02. It is an extremely effective technique for the extraction and cleanup of samples. One milliliter of cleaned up sample was filtered using PTFE syringe filter 0.25 µm in injection vials. The detection of pesticide residues was achieved using gas chromatography-mass spectrometry (GC-MS) equipped with capillary column HP-5ms ultra inert (30 m, ID 0.25 mm) **(Standards Policy and Strategy Committee, 2008).**

2.4. GC/MS analysis

GC-MS was configured with a flow rate of 2ml/min of Helium (99.999%) as the carrier gas. The column oven was initially set 40 °C for 2 min then ramped up at a rate of 30 °C/min to 220 °C, followed by a ramp of 5 °C/min to 260 °C and then with a final ramp of 20 °C/min to 280 °C where it at this temperature for 15 min. The transfer was adjusted to 280 °C and the injection volume was 1 µl. The mass spectrometer was used in SIM mode under electron impact at 70 eV, 230C for the ion source and 150℃ for MS-Quad.

2.5. Health risk assessment

Pesticide residue exposures may cause health risks to humans that need to be assessed. The estimated acceptable daily intake (EDI) is an indicator of these health hazards. Thus, the estimated acceptable daily intake (EDI) was calculated and compared to the acceptable daily intake (ADI) based on international standards **(FAO and WHO, 2022)**. The following formula was used to calculate the estimated acceptable daily intake (mg/kg body weight/day) of each pesticide found in the samples: $\mathbf{EDI = \sum C \times F / D \times W}$ where C is the pesticide residue concentration (mg/kg), F is the annual food intake per capita, D is the number of days in the year (365), and W is the body weight (60 kg). Additionally, the health risk index (HI) was calculated via EDI/ADI. A HI value of less than one means it's not harmful to human health **(Ahmed *et al*., 2016; Abuo El-kasem *et al*., 2023)**. According to FAOSTAT, (2022), the annual intake per person of tomato products and cucumber were 49.49 and 52.4 kg/capita/year, respectively, in Egypt **(FAOSTAT, 2022).**

2.6. Statistical analysis

The obtained data were statistically analyzed using one way ANOVA by the statistical package for social science (SPSS, version 26).

3. RESULTS

Nineteen pesticide residues of various classes were detected in 18 samples each of tomatoes and cucumber collected from different markets in the administrative centers of Fayoum. The detected residues include ethoprophos, atrazine, terbufos, diazinon, pirimicarb, pirimiphos methyl, malathion, chlorpyrifos methyl, cyprodinil, penconazole, chlorfenvinphos, profenofos, kresoxim- methyl, chlorfenapyr, diniconazole, ethion, epoxiconazole, bifenthrin and fenpropathrin. Maximum residue limits defined by the Codex Alimentarius Commission (MRLs Codex) and European Commission (MRLs EU) were used to compare the obtained data. In an overall survey of Fayoum governorate, we found that 83.3% and 72.2% of tomato samples contained chlorfenvinphos and ethoprophos, respectively, while only 11.1% contained bifenthrin. In the cucumber samples, 61.1, 55.6, and 55.6% of samples contained atrazine, terbufos, and chlorfenvinphos, respectively, while 11.1% of samples contained fenpropathrin.

3.1. Pesticide residues in tomato fruits

Data in Table 1 showed that Fayoum, Senoras and Tamiya Administrative Centers contain the highest percentage of pesticide residues in tomato fruits. Samples analyzed from Fayoum Center showed the presence of 8 insecticides (ethoprophos, pirimicarb, pirimiphos methyl, malathion, chlorfenvinphos, chlorfenapyr, ethion and fenpropathrin with concentrations above the maximum residue limit (MRLs Codex and EU). In addition, concentrations of five fungicides (diazinon, penconazole, kresoxim- methyl, diniconazole and epoxiconazole) were higher than the MRL. Nematicide (terbufos) and herbicide (atrazine) were also detected in samples. Chlorpyrifos methyl, cyprodinil and bifenthrin were found to be less than the limit of quantification (LOQ).

Most of the pesticide residues found in tomatoes collected from local markets in the Senoras region were above the maximum level, except for profenofos. There were also traces of some pesticides under detection limit by gas chromatography-mass spectrometry, such as cyprodinil, chlorfenapyr, epoxiconazole and fenpropathrin. Diazinon and malathion had the highest pesticide concentrations in Fayoum and Senoras samples. For Youssef Al-Siddiq region, 13 of 19 pesticide residues in tomato samples were found with concentrations greater than the maximum residue limit. Data obtained from the Tamiya region revealed that concentrations of 11 pesticide residues were above the MRL. Malathion had the highest concentration followed by atrazine and then diazinon. Conversely, the majority of tomato samples from the Abshway and Itsa regions had low concentrations of pesticide residues, which were below the quantitative limit. Also, the concentrations of ethoprophos, diazinon, malathion, and chlorfenvinphos pesticides were below the maximum residue limit in Ebshway region (Table 1).

Table 1. Residue pesticides (mg/kg) and maximum residue limits (MRL) in tomato traded in local markets of administrative centers in Fayoum Governorate

Active ingredient	Functional class	Residues (mg/kg) Mean ± Standard Error						MRLs codex (mg/kg)	MRLs EU (mg/kg)
		Fayoum	Senoras	Ebshway	Youssef Al-Siddiq	Tamiya	Itsa		
Ethoprophos	Insecticide	3.36±1.93	3.9±2.24	0.012±0.01	1.64 ±0.92	4.05±2.03	UDL	0.01	NR
Atrazine	Herbicide	2.75±1.52	2.67±1.47	< LOQ	< LOQ	4.34±0.34	< LOQ	NR	0.05
Terbufos	Nematicide	3.98±2.29	4.34 ±2.5	UDL	< LOQ	4.19±2.13	0.026±0.006	0.05 F	0.01
Diazinon	Fungicide	6.35±3.48	6.52 ±3.76	0.019±0.006	1.33±0.77	5.04±2.75	< LOQ	NR	0.1
Pirimicarb	Aphicide	5.48±3.16	1.04 ±0.60	UDL	2.44 ±1.41	UDL	< LOQ	1	0.5
Pirimiphos methyl	Insecticide	1.91±1.10	1.9±1.09	UDL	2.05±1.18	2.42±1.21	UDL	NR	NR
Malathion	Insecticide	5.17 ±2.98	8.56 ±4.76	0.017±0.003	0.01 ±0.005	7.8 ±3.96	< LOQ	0.5	0.02
Chlorpyrifos methyl	Insecticide	< LOQ	4.17±2.41	UDL	3.27±1.89	< LOQ	< LOQ	1	NR
Cyprodinil	Fungicide	< LOQ	UDL	UDL	2.47 ±1.42	< LOQ	< LOQ	0.5	1.5
Penconazole	Fungicide	2.24±1.29	2.39±1.38	UDL	3.17±1.83	3.06 ±1.53	< LOQ	0.09	0.1
Chlorfenvinphos	Insecticid/Acaricide	3.82±2.2	3.64±2.09	0.012±0.005	< LOQ	4.66±2.31	0.133±0.007	NR	0.01
Profenofos	Insecticide	4.48±2.59	4.35±2.51	UDL	1.82±1.05	6.67±3.36	UDL	10	10
Kresoxim- methyl	Fungicide	2.75±1.58	2.46±1.42	UDL	4.94±2.85	3.61±1.82	UDL	0.5	NR
Chlorfenapyr	Insecticide	6.40±3.7	UDL	UDL	2.61 ±1.51	UDL	0.019±0.005	0.4	0.01
Diniconazole	Fungicide	3.15±1.82	1.36 ± 0.78	UDL	2.40±1.39	1.80±0.9	UDL	NR	0.01
Ethion	Insecticide	1.38±0.8	3.18±1.83	UDL	3.94±2.27	4.18±2.09	UDL	NR	0.01
Epoxiconazole	Fungicide	3.51±2.03	UDL	UDL	4.44±2.56	UDL	< LOQ	NR	0.01
Bifenthrin	Insecticid/Acaricide	< LOQ	1.01 ±0.58	< LOQ	< LOQ	< LOQ	< LOQ	0.3	0.3
Fenpropathrin	Insecticid/Acaricide	1.02 ±0.6	UDL	UDL	3.12±1.80	UDL	< LOQ	1	0.01

MRLs Codex: Maximum Residue Limits of Codex Alimentarius Commission. MRLs EU: Maximum Residue Limits of European Commission; N.R: Not Registered; < LOQ; Less than Limit of quantification; UDL: Under Detection Limit.

3.2. Pesticide residues in cucumbers

The results in Table 2 indicate that most of the cucumber samples collected from Fayoum Centers markets were contaminated with pesticide residues. The highest regions were Fayoum and Tamiya, and the lowest were Itsa and Abshway. Ethoprophos, atrazine, terbufos, diazinon, pirimiphos methyl, malathion, chlorpyrifos methyl, penconazole, chlorfenvinphos, profenofos, kresoxim- methyl, diniconazole, ethion, and bifenthrin residues in samples of Fayoum Center recorded higher concentrations than the maximum limits (Codex and EU). While, levels of ethoprophos, pirimiphos methyl, chlorpyrifos methyl, penconazole, chlorfenvinphos and chlorfenapyr, were over MRLs in Senoras Center samples. Several pesticide residues in cucumber samples collected from Tamiya Center were detected, with chlorpyrifos having the highest concentration, while pirimiphos methyl, malathion, profenofos, kresoxim- methyl, diniconazole and epoxiconazole had the lowest concentrations. On the other hand, a lower level of pesticide residues in cucumber samples collected from Itsa, Abshway, and Youssef Al-Siddiq Centers were detected. At the Itsa Center, 12 pesticides were under detection limit by GC-MS in cucumber (ethoprophos, terbufos, pirimiphos methyl, malathion, chlorpyrifos, penconazole, profenofos, kresoxim-methyl, diniconazole, ethion, epoxiconazole and fenpropathrin). Four pesticides (bifenthrin, ethion, penconazole, pirimicarb and diazinon) had residues less than the limit of quantification (LOQ) of 10 µg/kg in cucumbers collected from Abshway region.

Table 2. Residue pesticides and maximum residue limits in cucumbers traded in local markets of administrative centers in Fayoum governorate

Active ingredient	Functional class	Residues (mg/kg) Mean ± Standard Error						MRLs Codex (mg/kg)	MRLs EU (mg/kg)
		Fayoum	Senoras	Ebshway	Youssef Al-Siddiq	Tamiya	Itsa		
Ethoprophos	Insecticide	3.33±1.92	1.07±0.62	0.02±0.002	UDL	< LOQ	UDL	0.01	NR
Atrazine	Herbicide	2.43±1.40	UDL	0.02 ±0.003	1.82±1.04	6.29±4.33	< LOQ	NR	0.05
Terbufos	Nematicide	2.97±1.71	< LOQ	0.02 ±0.002	3.26±1.87	< LOQ	UDL	NR	NR
Diazinon	Fungicide	3.74±2.15	< LOQ	< LOQ	< LOQ	4.78±2.58	< LOQ	NR	0.01
Pirimicarb	Aphicide	1.03±0.6	< LOQ	< LOQ	1.26±0.72	2.14±1.13	< LOQ	1	1
Pirimiphos methyl	Insecticide	1.79±1.03	1.81±1.04	UDL	UDL	UDL	UDL	NR	NR
Malathion	Insecticide	5.02±2.9	UDL	0.02 ±0.002	UDL	UDL	UDL	0.2	0.02
Chlorpyrifos	Insecticide	2.06±1.19	3.25±1.87	0.03±0.003	2.29±1.32	8.04±4.66	UDL	NR	0.01
Cyprodinil	Fungicide	0.52±0.30	UDL	UDL	0.44±0.25	2.09±1.45	< LOQ	0.5	0.5
Penconazole	Fungicide	4.09±2.36	2.99±1.73	< LOQ	UDL	4.11±2.10	UDL	0.06	0.06
Chlorfenvinphos	Insecticide/Acaricide	3.71±2.13	1.46±0.84	0.19±0.02	< LOQ	3.52±2.03	< LOQ	NR	0.01
Profenofos	Insecticide	4.25±2.46	UDL	UDL	UDL	UDL	UDL	NR	0.01
Kresoxim- methyl	Fungicide	3.38±1.95	UDL	UDL	UDL	UDL	UDL	0.5	NR
Chlorfenapyr	Insecticide	UDL	2.17±1.25	0.02±0.002	< LOQ	< LOQ	< LOQ	NR	0.01
Diniconazole	Fungicide	1.41±0.81	UDL	UDL	UDL	UDL	UDL	0.2	0.01
Ethion	Insecticide	3.26±1.88	UDL	< LOQ	3.34±1.93	5.07±2.62	UDL	NR	0.01
Epoxiconazole	Fungicide	UDL	UDL	UDL	UDL	UDL	UDL	NR	0.01
Bifenthrin	Insecticide/Acaricide	1±0.58	< LOQ	< LOQ	< LOQ	< LOQ	< LOQ	0.4	0.01
Fenpropathrin	Insecticide/Acaricide	UDL	UDL	UDL	UDL	7.39± 5.92	UDL	1	0.01

MRLs Codex: Maximum Residue Limits of Codex Alimentarius Commission. MRLs EU: Maximum Residue Limits of European Commission; NR: Not Registered; < LOQ; Less than Limit of quantification (10 µg/kg); UDL: Under Detection Limit.

3.3. Health Risk

The data presented in Tables 3 and 4 indicate that consuming pesticide-contaminated tomatoes and cucumbers may be harmful to humans. High Health risk index (HI) values above one indicates potential harm to consumers. The results in Table 3 show that there is a risk associated with consuming tomatoes in Fayoum, Senoras and Tamiya regions. The health risk index values were 20, 18, 15, and 12 for ethoprophos, chlorfenvinphos, terbufos, and atrazine, respectively, in tomatoes from the Fayoum region. Similarly, the values were 22.5, 16, 15, and 12 for the same pesticides in the Senoras region, and 22.5, 20, 20, 15, and 20 for the Tamiya region. However, in the Youssef Al-Siddiq region, the HI values ranged from 10 for ethoprophos to 1.45 for epoxiconazole.

Data in Table 4 showed the health risk index (HI) and estimated daily intake (EDI) of all detected pesticides in cucumber samples from Fayoum governorate. The results for cucumbers revealed the two highest health risk index values for ethoprophos and chlorfenvinphos pesticides in the Fayoum and Senoras samples. The HI values were recorded as 20 and 18 for Fayoum cucumbers and 7.5 and 6 for Senoras cucumbers. The highest health risk index was found for atrazine and ethion, with values of 32 and 6 in

Tamiya samples and 8 and 4 in Youssef Al-Siddiq samples, respectively. Consequently, the presence of these pesticides in the samples represents a health risk through the consumption of fresh cucumbers and tomatoes contaminated with pesticides.

Table 3. Acceptable daily intake and health risk of pesticide residues above maximum residue Limit in tomatoes

Residue pesticides detected	Fayoum			Senoras		Youssef Al-Siddiq		Tamiya	
	(ADI) (mg/kg B.W)	EDI (mg/kg B.W/d)	(HI) (EDI/ADI)	EDI (mg/kg B.W/d)	(HI) (EDI/ADI)	EDI (mg/kg B.W/d)	(HI) (EDI/ADI)	EDI (mg/kg B.W/d)	(HI) (EDI/ADI)
Ethoprophos	0.0004	0.008	20*	0.009	22.5*	0.004	10*	0.009	22.5*
Atrazine	0.0005	0.006	12*	0.006	12*	-	-	0.01	20*
Terbufos	0.0006	0.009	15*	0.009	15*	-	-	0.009	15*
Diazinon	0.01	0.014	1.4*	0.015	1.5*	0.003	0.3	0.011	1.1*
Pirimicarb	0.02	0.012	0.6	0.002	0.1	0.006	0.3	-	-
Pirimiphos methyl…	0.03	0.004	0.13	0.004	0.13	0.005	0.17	0.005	0.17
Malathion	0.3	0.012	0.04	0.091	0.30	-	-	0.018	0.06
Chlorpyrifos methyl	0.01	-	-	0.009	0.9	0.007	0.7	-	-
Cyprodinil	0.03	-	-	-	-	0.006	0.2	-	-
Penconazole	0.03	0.005	0.16	0.005	0.16	0.007	0.23	0.007	0.23
Chlorfenvinphos	0.0005	0.009	18*	0.008	16*	-	-	0.01	20*
Profenofos	0.03	-	-	-	-	-	-	-	-
Kresoxim-methyl	0.3	0.006	0.02	0.006	0.02	0.011	0.04	0.008	0.03
Chlorfenapyr	0.03	0.014	0.47	-	-	0.006	0.2	-	-
Diniconazole	0.03	0.007	0.23	0.003	0.1	0.005	0.17	0.004	0.13
Ethion	0.002	0.003	1.5*	0.007	3.5*	0.009	4.5*	0.009	4.5*
Epoxiconazole	0.0069	0.008	1.16*	-	-	0.01	1.45*	-	-
Bifenthrin	0.01	-	-	0.002	0.2	-	-	-	-
Fenpropathrin	0.03	0.002	0.07	-	-	0.007	0.23	-	-

ADI: Acceptable Daily Intake according to Codex Alimentarius Commission, EDI: Estimated Daily Intake, HI: Health risk index; * this means it causes hazards.

Table 4. Acceptable daily intake and health risk of pesticide residues above maximum residue Limit in cucumbers

Residue pesticides detected	Fayoum			Senoras		Youssef Al-Siddiq		Tamiya	
	(ADI) (mg/kg B.W)	EDI (mg/kg B.W/d)	(HI) (EDI/ADI)	EDI (mg/kg B.W/d)	(HI) (EDI/ADI)	EDI (mg/kg B.W/d)	(HI) (EDI/ADI)	EDI (mg/kg B.W/d)	(HI) (EDI/ADI)
Ethoprophos	0.0004	0.008	20*	0.003	7.5*	-	-	-	-
Atrazine	0.0005	0.006	12*	-	-	0.004	8*	0.016	32*
Terbufos	0.0006	0.007	11.67*	-	-	0.008	13.33*	-	-
Diazinon	0.01	0.009	0.9	-	-	-	-	0.011	1.1*
Pirimicarb	0.02	-	-	-	-	-	-	0.005	0.25
Pirimiphos methyl…	0.03	0.004	0.13	0.004	0.13	-	-	-	-
Malathion	0.3	0.012	0.04	-	-	-		-	
Chlorpyrifos methyl	0.01	0.005	0.5	0.008	0.8	0.005	0.5	0.019	1.9*
Cyprodinil	0.03	-	-	-	-	-	-	0.005	0.17
Penconazole	0.03	0.098	3.27*	0.007	0.23	-	-	0.01	0.33
Chlorfenvinphos	0.0005	0.009	18*	0.003	6*	-	-	0.008	16*
Profenofos	0.03	0.01	0.33	-	-	-	-	0. 011	0.37
Kresoxim- methyl	0.3	0.008	0.03	-	-	-	-	-	-
Chlorfenapyr	0.03	-	-	0.005	0.17	-	-	-	-
Diniconazole	0.03	0.034	1.13*	-	-	-	-	-	-
Ethion	0.002	0.008	4*	-	-	0.008	4*	0.012	6*
Epoxiconazole	0.0069	-	-	-	-	-	-	-	-
Bifenthrin	0.01	0.002	0.2	-	-	-	-	-	-
Fenpropathrin	0.03	-	-	-	-	-	-	0.18	6*

ADI: Acceptable Daily Intake according to Codex Alimentarius Commission, EDI: Estimated Daily Intake, HI: Health risk index; * this means it causes hazards

4. DISCUSSION

The current study was carried out in Fayoum Governorate and confirmed the presence of 19 pesticides in tomatoes and cucumbers sold in local markets. Multiple pesticide concentrations in samples obtained in Fayoum, Senoras, and Tamiya exceeded the maximum residue limit. This may be due to farmer's poor practice in applying pesticides. The most detected pesticides in this study were insecticides, followed by fungicides. Most of them were organophosphate insecticides such as ethoprophos, chlorfenvinphos, terbufos, dizinon, pyrimiphos methyl, malathion, chlorpyrifos methyl, chlorfenvinphos, and profenofos. This may be associated with excessive application of pesticides from the organophosphate group in the study regions. In the same text, 56.4% of determined residues were insecticides and 43.6% were fungicides in tomatoes analyzed from markets in five Egyptian cities (Al-Obour, Al-Salheia El-Gadida, Giza, Zagazig, and Fayed) **(Abuo El-kasem *et al*., 2023)**. Similar investigations revealed higher concentrations of pesticides in vegetables exceeding MRLs based on the Codex Alimentarius Commission and European Commission. Tomatoes sold in urban markets in Ouagadougou, Burkina Faso, were contaminated with DDT, acetamiprid, lambda-cyhalothrin, and chlorpyrifos. Additionally, these pesticides were above the maximum residue levels **(Dione *et al*., 2023).**

Chlorpyrifos, α-endosulfan, *β*-endosulfan, and cypermethrin were detected in tomato samples obtained from Dar es Salaam Markets, Tanzania. Contaminant concentrations exceeded the maximum residue limits in 41.7% of the tomatoes **(Mahugija *et al*., 2017)**. In another study conducted in the central market of Khartoum, different pesticides, such as diazinon, malathion, chlorpyrifos, profenofos cypermethrin, and deltamethrin, were detected in tomatoes **(Ali *et al.*, 2020)**. In contrast, all detected pesticides in samples of tomatoes collected from local Saudi Arabia markets, were below the maximum residue level **(Abd-Elhaleem, 2020)**.

In this study, a hazard index was utilized to highlight the risks that pesticides pose to human health. Our findings also indicated that the intake of fresh tomatoes and cucumbers in Fayoum governorate may represent possible hazards due to the presence of ethoprophos, chlorfenvinphos, terbufos, and atrazine, which showed the highest HI values. A previous study showed that pesticides pose similar health hazards for humans. Organophosphate pesticides may accumulate or be deposited into plant tissues **(Jeong *et al*., 2012)**. Some studies have reported that organophosphate compounds are carcinogenic, cause endocrine disruption, and inhibit cholinesterase **(Sharma *et al*., 2010; Yadav *et al*., 2016; Bhandari *et al.*, 2019)**. Atrazine is a widely utilized herbicide that can persist in soils for several months and was eliminated in 2003 by the European Union **(Bethsass and Colangelo, 2006),** where it disturbed the endocrine system and was considered a possible carcinogen **(Hong *et al.*, 2022)**. A comparable study found that organophosphate pesticides had the greatest risk index values (HI), indicating a higher risk to health **(Bhandari *et al*., 2019).** However, there are some practices that have reduced pesticide residues in vegetables, such as washing with a salt solution peeling and cooking **(Reiler *et al*., 2015; Ahmed *et al*., 2024)**. Ultimately, our results revealed the presence of different pesticide residues in some samples. Additionally, there were potential health risks for consumers after cumulative exposure to some pesticides in tomatoes and cucumbers sold in different Fayoum markets.

5. CONCLUSION

This study highlights the occurrence of pesticide residue levels higher than MRL in tomato and cucumber fruits from local markets, which are commonly consumed fresh. Hence, the necessity for sufficient supervision and monitoring at local vegetables markets to ensure their safety on the consumers and educating consumers about the risks associated with pesticide residue exposure. Additionally, guiding farmers on good practices for using pesticides is crucial. Developing advanced techniques for detecting the lowest levels of pesticide residues in food.

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