Occurrence of pesticide residues in some commonly consumed fruits from Egyptian markets.

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***Received:** 07-Feb-2022, Manuscript No. AAJGMB-22-53649; **Editor assigned:** 09-Feb-2022, PreQC No. AAJGMB-22-53649(PQ); **Reviewed:** 23-Feb-2022, QC No AAJGMB-22-53649; **Revised:** 28-Feb-2022, Manuscript No. AAJGMB-22-53649(R); **Published:** 07-Mar-2022, DOI:10.35841/aajgmb-6.3.106*

Abstract

The purpose of this study was to investigate pesticide residues in fruits from the Egyptian Markets. A total of 18 samples of fresh fruits samples collected from Egyptian markets during November to December 2019. Selection of fresh fruits based on their popularity and consumption at all socioeconomic levels during the winter season. Samples were subjected to pesticide residues analysis using multi residues standard method (QuEChERs). The determination of residues carried out using GC-MS/MS and LC-MS/MS. The samples were analyzed using an accredited method that is capable of quantify 450 pesticide residues from different pesticide groups. Thirty-one pesticides were detected in all analyzed samples. All samples had detectable pesticide residues. Whereas, 100% (18 samples) had detectable pesticide residues of which contaminated at 55.55% level above the MRLs and 44.44% (8 samples) had residues below the MRLs. Whereas, all samples were contaminated with tomato, orange and guava (100% respectively) with 16.66%, 83.33% and 66.66% exceeded the MRLs, respectively. The hazard index (HI %), representing the long–term risk assessment was in the range of 0.135692%–1.978846% in tomato samples, 0.019972%–8.737660% in guava samples, 0.415385%–49.326923% in orange samples and 0.415385%–49.326923% in orange samples of the ADI's. The highest exposure was observed for carbendazim in tomato samples, omethoate in guava samples, dimethoate in orange samples of ADI respectively. The contribution to the ADI shows that all the intakes of pesticide residues in fruit samples are still within acceptable limits, as HRI % value less than 100% is considered as safe for human health.

Keywords: Pesticide residues, Fruits, Egypt, Risk assessment, Monitoring.

Abbreviation: ADI: Acceptable daily intake; HRI: Hazard risk index; EMR: Eastern Mediterranean Region; WHO: World Health Organization; EDI: Estimated daily intake; MRLs: Maximum residues levels; LC: Liquid chromatograph; GC: Gas chromatograph; FAO: Food and Agriculture Organization; EFSA: European Food Safety Authority; ARfD: Acute Reference Dose; GAP: Good Agricultural Practices

Highlights

Dietary risk assessment of Pesticide Residues in guava, tomato and orange:

1. The consumption rate of each commodity converted into grams per week is determined on the basis of the average sample weight and then divided by seven to obtain the average intake per day.
2. The mean daily intake from each item (selected fruits) was calculated in g/day for each participant.
3. The mean pesticides residue that was measured in each food item in mg/g.

Estimated mean daily pesticide residues intake from each food items (mg/day) were calculated by multiplying item number (2) and item number (3), then was divided by participant's body weight (78 kg) to get the mean daily intake in mg/kg/day so as to be compared to the acceptable daily intake (ADI) of each pesticide.

Where EDI is the estimated daily intake, ADI is the acceptable daily intake. HRI value more than 1 is considered as not safe for human health.

***Citation:** Agamy NFM, Mohmoud El Marsafy A, Abou El Ela NE, et al. Occurrence of pesticide residues in some commonly consumed fruits from Egyptian markets. J Food Sci Nutr. 2022;5(1):101*

Introduction

Food borne disease by World Health Organization (WHO) was estimated to be about 600 million; almost 1 in 10 people in the world fall ill after eating contaminated food and 420,000 die every year, resulting in the loss of 33 million healthy life years (DALYs). The 2015 WHO report on the estimates of the global burden of foodborne illness presented the first-ever estimates of illness burden caused by 31 food borne agents (bacteria, viruses, parasites, toxins and chemicals) at global and regional level [1].

The origins of chemical contaminants are various from the farm to the plate; namely soil, environment, disinfection by-products, personal care products, air, water, and packaging material. Chemical contaminants inhibit almost all the mass-produced everyday use products such as disinfectants, plastics, detergents, deodorants, pesticides, and so on. Even the consumed food and water are not safe from the invasion of chemicals in unsafe concentrations. Food contamination, whether accidental or intentional, is an unfortunate act that brings in its wake numerous and serious implications on the human health. Food contamination has been recorded in history as early as 8,000 years ago; however, the growth in agribusiness and globalizations has aided the problem in spreading all over the planet [2].

Fruits and vegetables represent both a considerable contribution to a healthy dietary pattern of the population and a source of income for countries exporting part of their production. Countries of the Eastern Mediterranean Region (EMR) have undergone rapid urbanization and changes in lifestyle and consumer demands. These changes have had a profound effect on food production and consumption. The demand is, in particular, driving farmers to apply pesticides to protect crops and increase yield. As a result, pesticide residues are often found in fruits and vegetables which can be harmful to humans when consumed [3]. According to WHO consumption of fruits and vegetables in Europe constituted over 30% of consumer diet [4]. Eating a diet rich in fruits and vegetables is associated with a decreased risk of many chronic illness, including heart disease, stroke, high blood pressure, diabetes, and some cancers. Research also has found that replacing foods of high energy density (high calories per weight of food) with foods of lower energy density, such as fruits and vegetables, can be an important part of a weight-management strategy [5].

Besides their nutrient value, these products can be a source of harmful substances i.e. pesticide residues. Because fruit and vegetables are treated directly with plant protection products and are mainly eaten raw, they are the major source of pesticide residue intake for humans. Human intake of toxic substances due to pesticide residues in food commodities can be much higher than intake of these substances related to water consumption and air inhalation [6].

Pesticides tend to bio-concentrate and bio-magnify the food chains, causing a variety of reproductive, carcinogenic, immunological, neurological and do there adverse effects for both animals and humans [7]. Many human health related concerns are associated with pesticides, ranging from short-term impacts such as headaches and nausea, to chronic impacts, such as various cancers, birth defects, infertility, and endocrine disruption [8,9].

It is very important to monitor pesticides in fruits and vegetables and to assess if they are in the safe limits below MRLs or they pose a risk to human health. In Egypt there are official monitoring systems for imported and exported fruits while the local market is not adequate markets, consequently the safety of fruits and vegetables sold in local markets depends on the honesty of farmers. Therefor the purpose of this study is to assess the risk of some pesticide residues in commonly used fruits in local markets.

Materials and Methods

Sampling

Eighteen samples of three fresh fruits including tomato, guava and orange were collected at random basis from three central markets in Alexandria representing three districts (Bab Omar bash market, Bakkous market, and Mandara market). Sampling was conducted according to the international standard guideline [10]. Sex different samples were taken for analysis (2 kilogram each). Samples were kept in a separate sterile polyethene bag, sealed, labelled with a unique sample identity, placed in ice chest box then transported to laboratory. Samples were stored at 4°C until analysis. Samples of the selected fruits were analyzed for pesticide residues using the accredited (QuEChERS) method. The method allowed the determination of different pesticide chemical groups. LC-MS/MS and GC–MS/MS will be used for residues quantification [11].

Pesticide residues analysis

Four hundred and fifteen (450) pesticides of different pesticide chemical groups either currently registered or banned in Egypt were subjected to analysis. The detail of the analytical method was described by [12-14].

The (QuEChERS) method was used for analysis of or pesticide residues in fruits. The extraction procedure is based on liquid–liquid partitioning with acetonitrile followed by a cleanup step with dispersive-SPE. This method nowadays is the official standard method in many laboratories in the world; it's known as the standard method of European Committee for Standardization/Technical Committee 275 (2007) for foods of plant origin: prEN 15662.

Quality assurance

The analytical method and instruments were validated as part of a laboratory quality assurance system and were accredited according to ISO/IEC 17025:2005 by the Finnish Accreditation Service (FINAS), Finland. Codex quality assurance criteria were followed to determine the performance of the standard method. The average recoveries of these pesticides at different concentration levels varied between 70%-120%.

The reproducibility expressed as relative standard deviation was less than 25%. The limit of quantitation started at 0.01

mg/kg and up depending on the pesticide type and detection module. The measurement uncertainty expressed as expanded uncertainty in terms of relative standard deviation (at 95 % confidence level) is lower than the default value set by the EU (± 50%).

Apparatus

LC-MS/MS system: An Agilent 1200 series liquid chromatograph system equipped with Applied Biosystems (API 4000 Qtrape & API 5500 Qtrape) tandem mass spectrometers with electro sprary ionisation (ESI) interface were used. Separation was performed on a C18 column ZORBAX Eclipse XDB- C18 4.8 mm × 150 mm, 5 µm particle size. The injection volume was 25 µl. Agradient elution program was at 0.3 ml/min flow rate, in which one reservoir contained 10 mM ammonium formate solution in MeOH: H_2O (1:9 V/V) and the other contained methanol. The ESI source was used in the positive mode, and tNitrogen was used as nebulizer gas, curtain gas, heater gas and collision gas according to manufacturer's settings; source temperature was 300°C, ion spray potential 5500 V, decluster potential and collision energy were optimized using a Harvard apparatus syring pump. The Multiple Reactions monitoring mode (MRM) was used in which one MRM was used for quantitation and other was used for confirmation.

GC-MS/MS analysis: Agilent Gas Chromatograph 7980A equipped with tandem mass spectrometer 7000 B Quadrupole, El source was used to perform analysis by using HP-5MS 5% phenyl methyl siloxane capillary column (30 m length×0.25 mm id×0.25 µm film thickness). Samples were injected in a splitless mode and helium was used as carrier gas (1 ml/min). Injector temperature was 250°C, transfer line temperature was 285 °C, ion source temperature was 280°C and quadrupole temperature was 150°C. The GC oven temperature was programmed to initially held at 70°C for 2 min then increased to 150°C at 25°C/min (held for 0 min), and raised to 200°C the rate of 3°C/min (held for 0 min), then went up from 200 to 280 °C at 8°C/min (held for 10 min). This resulted in a total run time of 42 minutes and a complete separation of all the analytes.

Reagents

Solvents and chemicals described in the standard method CEN 275, 2007

Pesticides reference standards

All reference materials are certified provided by Dr. Ehrenstorfer Gmbh, Gogginger Str. 78 D- 8900 Augoburg.

Estimation of the daily intake of pesticides

The dietary intake of any particular pesticide residue in a given food is obtained by multiplying the residue level in the food by the amount of that food consumed. Total intake of the pesticide residue is then obtained by summing the intakes from all commodities containing the residue of concern [15]. In the current study the dietary intakes of pesticides were assessed by combining data of concentrations of pesticides found in different fruits and the daily amount of consumption of these fruits. Food consumption data were collected using a quantitative food frequency questionnaire structured by the National Cancer Institute of the USA [16]. The questionnaire was translated into Arabic and some items were modified to fit Egyptian food habits. A total of 400 adults from the Alexandria governorate participated. Adults in Bab Omar bash, Bakkous, and Mandara of both sexes who accepted to participate in the study. Adults were asked about the frequency of consumption and amount of selected fruits during a week and Self-reported body weight by adults in Bab Omar bash, Bakkous, and Mandara who accepted to participate in the study. The estimated daily intake (EDI) of pesticide residues was calculated as follows:

1. The consumption rate of each commodity converted into grams per week is determined on the basis of the average sample weight and then divided by seven to obtain the average intake per day.
2. The mean daily intake from each item (selected fruits) was calculated in g/day for each participant.
3. The mean pesticides residue that was measured in each food item in mg/g.
4. Estimated mean daily pesticide residues intake from each food items (mg/day) was calculated by multiplying item number (2) and item number (3), then was divided by participant's body weight (78 kg) to get the mean daily intake in mg/kg/day so as to be compared to the acceptable daily intake (ADI) of each pesticide [17].

Pesticide intake (mg/kg bw/day)=[pesticide residue (mg kg-1)×consumption (kg/day)] ÷Body weight (kg).

Hazard Risk Index (HRI) analysis

HRI of the residues was computed using the results and the following equation modified after European Food Safety Authority (EFSA) [18]:

HRI=EDI/ADI

Where EDI is the estimated daily intake, ADI is the acceptable daily intake. HRI value more than 1 is considered as not safe for human health [19].

Results and Discussion

A total of 18 samples of fruits were collected from three local markets in Alexandria Governorates during 2019. All samples were subjected to multi residues analysis for 450 pesticide residues that are widely used or banned in Egypt using the standard method CEN 275, 2007. The new techniques using LC-MS/MS with GCMS/ MS allowed the detection of a wide range of residues with low quantification levels to achieve the international demands. By this method, it could precisely identify the small quantity (<LOQ) for each compound and the number of pesticides sought in the analytical scope have been increased. The analyzed wide range include many groups of pesticides such as, organophosphorus and Carbamates, organochlorine, pyrethroids, and other groups of pesticide that are widely used or banned in Egypt.

Table 1. *Pesticide residues detected in orange samples collected from three local central markets in Alexandria Governorate (EGYPT) during 2019.*

Contaminated samples n=6		Detected pesticides	Pesticides Level (mg/kg)		Mean (mg/kg)	Frequency		MRLs (mg/kg)		No.of violated Compound		No. of violated Samples	
No.	%		Min	Max		No.	%	EU	Codex	No.	%	No.	%
6	100	Carbendazim	0.01	0.3	0.166	5	23.8	0.2	1	2	40	5	83.33
		Chlorpyrifos	0.01	0.2	0.1366	3	14.28	1.5	1	0	0		
		Dimethoate	0.01	0.03	0.02	2	9.52	0.01	5	0	0		
		Imazalil	0.01	0.24	0.125	2	9.52	5	8	0	0		
		Malathion	0.01	0.02	0.015	2	9.52	2	7	0	0		
		Metalaxyl	0.1	0.1	0.1	1	4.76	0.7	5	0	0		
		Omethoate	0.02	0.17	0.095	2	9.52	0.01	no MRL	1	20		
		Ortho-Phenyl Phenol (OPP)	0.19	0.19	0.19	1	4.76	10	10	0	0		
		Profenofos	0.01	0.03	0.02	3	14.28	0.01	0.01	2	40		

Table 2. *Pesticide residues detected in guava samples collected from three local central markets in Alexandria Governorate (EGYPT) during 2019.*

Contaminated samples n=6		Detected Pesticides	Pesticides Level (mg/kg)		Mean (mg/kg)	Frequency		MRLs (mg/kg)		No. of violated Compound		No. of violated Samples	
No.	%		Min.	Max		No.	%	EU	Codex	No.	%	No.	%
6	100	Carbendazim	0.01	0.09	0.035	6	23	0.1	no MRL	0	0	4	66.66
		Chlorpyrifos	0.02	0.22	0.11	4	15.38	0.1	no MRL	2	18.18		
		Cyfluthrin	0.01	0.01	0.01	2	7.69	0.02	no MRL	0	0		
		Cypermethrin	0.01	0.06	0.026	3	11.53	0.05	no MRL	1	9.09		
		Dimethoate	0.02	0.17	0.07	4	15.38	0.01	no MRL	4	36.36		
		Lambda-Cyhalothrin	0.02	0.02	0.02	1	3.84	0.01	no MRL	1	9.09		
		Omethoate	0.01	0.05	0.035	4	15.38	0.01	no MRL	3	27.27		
		Piperonyl butoxide	0.02	0.02	0.02	1	3.84	no MRL	no MRL	0	0		
		Profenofos	0.01	0.01	0.01	1	3.84	0.01	no MRL	0	0		

Table 1 showed shows that all orange samples (100%) had detectable pesticide residues established by the Codex Alimentarius and 5 samples (83%) exceeding the MRLs. No orange samples without pesticides residues.

Table 2 shows that all guava samples (100%) had detectable pesticide residues established by the Codex Alimentarius and 4 samples (66.7%) exceeded the MRLs. There were no guava samples without pesticides residues. Comparing the current data with the previous monitoring results of Guava and Orange samples at Egyptian local markets in 2007 obtained by Gad Alla et al. [20] lower contamination percentages in Guava samples were noticed which a 40% while a lower contamination percentage was observed in orange samples which was 75% comparing with the current results.

The rates of outcome in the present study were similarly the residue levels obtained through the study of pesticide residues in Guava and Orange samples at Egyptian markets in 2010 reported by Gad Alla et al. [21] who detected 100% contamination in guava and orange due to the residues of OP's and PY''s, Table 1 and Table 2.

In guava samples the most frequently detected pesticide was carbendazim, followed by chlorpyrifos, dimethoate and omethoate and the five violated compounds in guava samples were chlorpyrifos, cypermethrin, dimethoate, lambda-cyhalothrin and omethoate. The same result was reported by Gad Alla et al. [20] at Egyptian markets where the violated compounds in guava samples were Chlorpyrifos, Acetamiprid, Dimethoate, Cyfluthrin, Cypermethrin and Imidacloprid, while the highest frequently detected pesticide was Cypermethrin, followed by Chlorpyrifos and Carbendazim.

In orange samples the most frequently detected pesticide was carbendazim, followed by chlorpyrifos, profenofos, dimethoate, imazalil, malathion, metalaxyl and ortho-phenyl phenol (opp) and the violated compounds in orange samples were carbendazim, dimethoate, omethoate and profenofos. Comparing the current data with the previous monitoring results of orange samples reported by Gad Alla et al. [21] at Egyptian markets the highest frequently detected pesticide was L-Cyhalothrin, followed by 2-Phenyl Phenol and Thiabendazole while the violated compounds in orange samples were Fenitrothion, Phenthoate and Profenofos.

Table 3 show that 6 tomato samples (100%) had detectable pesticide residues with MRLs less than established by the Codex Alimentarius and 1 sample (17%) exceeded the MRLs. no tomato samples without pesticides residues. Comparing the current data with the previous monitoring results of tomato samples reported by Emtithal [22] at Egyptian markets, there was no pesticide residues were detected in 17 Tomato samples (28.33%), from a total of 43 Tomato samples 71.7% had detectable pesticide residues, 5 Tomato samples (8.3%) were exceeding the MRLs established by the Codex Alimentarius.

In tomato samples the most frequently detected pesticide was chlorpyrifos, followed by chlorfenapyr and the violated compounds in tomato samples were chlorfenapyr and chlorpyrifos. These results are not in agreement with reported by Emtithal [22] at Egyptian markets no violated compounds in

Table 3. *Pesticide residues detected in tomato samples collected from local markets located in three centers in Alexandria Governorate (EGYPT) during 2019.*

Contaminated samples n=6		Detected Pesticides	Pesticides level(mg/kg)		Mean (mg/kg)	Frequency		MRLs (mg/kg)		No. of violated Compound		No. of violated Samples	
No.	%		Min	Max		No.	%	EU	codex	No.	%	No.	%
6	**100**	Carbendazim	**0.02**	**0.03**	**0.025**	2	9.52	0.3	0.5	0	**0**	**1**	**16.66**
		Chlorfenapyr	**0.01**	**0.02**	**0.012**	5	23.8	0.01	0.4	1	**50**		
		Chlorpyrifos	**0.01**	**0.3**	**0.057**	6	28.5	0.1	no MRL	1	**50**		
		Cyfluthrin	**0.02**	**0.03**	**0.025**	2	9.52	0.05	0.2	0	**0**		
		Difenoconazole	**0.01**	**0.01**	**0.01**	2	9.52	2	0.6	0	**0**		
		Lambda-Cyhalothrin	**0.01**	**0.04**	**0.025**	2	9.52	0.07	0.3	0	**0**		
		Thiophanate-methyl	**0.3**	**0.4**	**0.35**	2	9.52	1	0.5	0	**0**		

Table 4. *Distribution of the analysed fruits and vegetables samples (guava, orange and tomato) according to the presence of pesticide residues and relative to the maximum residues limits (MRLs).*

Commodity	No. of samples	Without residues		With residues< MRLs		With residues > MRLs	
Guava	6	0	0%	2	33.33%	4	66.66%
Orange	6	0	0%	1	16.66%	5	83.33%
Tomato	6	0	0%	5	83.33%	1	16.66%
Total	18	0	0%	8	44.44%	10	55.55%

Table 5. *Acceptable daily intake of the all detected pesticide residues, the estimated hazard index, the hazard index, percentage of HRI and pesticide estimated daily intake based on tomato consumption data (Alexandria 2019).*

The detected pesticide	Mean mg/kg	Dietary intake g/day	EADI mg/kg.bw /day	ADI mg/kg bw	HRI	Hazard Index %	Health Risk (>1 Risk <1 not risk)
Carbendazim	0.025	132.3	0.0000424	0.03	0.001413	1.978846%	Not risk
Chlorfenapyr	0.012	132.3	0.0000204	0.015	0.001360	0.135692%	Not risk
Chlorpyrifos	0.057	132.3	0.0000967	0.01	0.009670	0.966808%	Not risk
Cyfluthrin**	0.025	132.3	0.0000424	0.02	0.002120	0.212019%	Not risk
Difenoconazole	0.01	132.3	0.0000170	0.01	0.001700	0.169615%	Not risk
Lambda-Cyhalothrin**	0.025	132.3	0.0000424	0.02	0.002120	0.212019%	Not risk
Thiophanate-methyl**	0.35	132.3	0.0005937	0.08	0.007421	0.742067%	Not risk

Table 6. *Acceptable daily intake of the all detected pesticide residues, the estimated hazard index, the hazard index, percentage of HRI and pesticide estimated daily intake based on guava consumption data (Alexandria 2019).*

The detected pesticide	Mean mg/kg	Dietary intake g/day	EADI mg/kg.bw /day	ADI mg/kg bw	HRI	Hazard Index %	Health Risk (>1 Risk <1 not risk)
Carbendazim	0.035	77.89	0.0000350	0.03	0.001167	0.116502%	Not risk
Chlorpyrifos	0.11	77.89	0.0001098	0.01	0.010980	1.098449%	Not risk
Cyfluthrin**	0.01	77.89	0.0000100	0.02	0.000500	0.049929%	Not risk
Cypermethrin**	0.026	77.89	0.0000260	0.013	0.002000	0.199718%	Not risk
Dimethoate	0.07	77.89	0.0000699	0.01	0.006990	0.699013%	Not risk
Lambda-Cyhalothrin**	0.02	77.89	0.0000200	0.02	0.001000	0.099859%	Not risk
Omethoate	0.035	77.89	0.0000350	0.0004	0.087500	8.737660%	Not risk
Piperonyl butoxide	0.02	77.89	0.0000200	0.1	0.000200	0.019972%	Not risk
Profenofos	0.01	77.89	0.0000100	0.03	0.000333	0.033286%	Not risk

Table 7. *Acceptable daily intake of the all detected pesticide residues, the estimated hazard index, the hazard index, percentage of HRI and pesticide estimated daily intake based on orange consumption data (Alexandria 2019).*

The detected pesticide	Mean mg/kg	Dietary intake g/day	EADI mg/kg.bw /day	ADI mg/kg bw	HRI	Hazard Index %	Health Risk (>1 Risk <1 not risk)
Carbendazim	0.166	162	0.0003448	0.03	0.011493	1.149231%	Not risk
Chlorpyrifos	0.1366	162	0.0002837	0.01	0.028370	2.837077%	Not risk
Dimethoate	0.02	162	0.0000415	0.01	0.004150	0.415385%	Not risk
Imazalil	0.125	162	0.0002596	0.03	0.008653	0.865385%	Not risk
Malathion	0.015	162	0.0000312	0.002	0.015600	1.557692%	Not risk
Metalaxyl	0.1	162	0.0002077	0.05	0.004154	0.415385%	Not risk
Omethoate	0.095	162	0.0001973	0.0004	0.862000	49.326923%	Not risk
Ortho-Phenyl Phenol (OPP)	0.19	162	0.0003946	0.4	0.000709	0.098654%	Not risk
Profenofos	0.02	162	0.0000415	0.03	0.001383	0.138462%	Not risk

Citation: *Holmes RS. Comparative structures and evolution of sterol-C5-desaturase (SC5D) genes and proteins: A major role in cholesterol biosynthesis. J Food Sci Nutr. 2022;5(1):101*

tomato samples while the highest frequently detected pesticide was Chlorpyrifos, followed by Diazinon and Profenofos. Table 4 show different commodities with and without residue levels and percent residue levels compared to (MRLs) established by Codex Alimentarius Commission [CAC] [23]. No samples without pesticides residues. Whereas, 100% (18 samples) had detectable pesticide residues of which 55.55% contaminated at level above the MRLs and 44.44% (8 samples) had residues below the MRLs.

Dietary exposure and dietary risk assessment

Tables 5-7 show the pesticides, which were the most frequently detected in the samples, were chosen for the dietary intake assessment and the chronic risk assessment is performed for all commodities. The average pesticide residues levels were calculated by using residue data. The results of the estimated daily intake (EADI) calculation are reported separately for each pesticide in an exposure assessment. If the acceptable daily intake (ADI) was not exceeded in any commodity, a chronic consumer risk can be excluded.

Table 5 shows that the intake of pesticide residues did not exceed the ADI in tomato samples. The hazard index ranges from 0.135692% of the ADI for the chlorfenapyr to 1.978846% of the ADI for the carbendazim.

Table 6 shows that the intake of pesticide residues did not exceed the ADI in guava samples. The hazard index ranges from 0.019972% of the ADI for the piperonyl butoxide to 8.737660% of the ADI for the omethoate.

Table 7 shows that the intake of pesticide residues did not exceed the ADI in orange samples. The hazard index ranges from 0.415385% of the ADI for the metalaxyl and dimethoate to 49.326923% of the ADI for the omethoate.

The present results showed that, the long-term exposure of the Egyptian consumers to pesticide residues through the consumption of raw fruits (orange, tomato and guava) does not associate with health risk. However, it should be borne in mind that the current study is limited to a small group of fruits. Moreover, the estimated risk assessment via long-term exposure is based on toxicological evaluation of the single compounds and not based on an evaluation of cumulative exposure to multiple pesticide residues in crops.

In Egypt, monitoring programs for pesticide residues in foodstuffs have been carried out, mostly by the Central Laboratory of Residue Analysis of Pesticides and Heavy Metals in Food, Ministry of Agriculture, Egypt [24-27]. Such programs do not reflect the situation in the whole of Egypt, and they are not followed up by evaluation of exposure levels and risks to humans [28].

In general, the MRLs are always set far below levels considered to be safe for humans. It should be understood that MRLs are not safety limits, a food residue can have higher level than MRL but can still be safe for consumption [29]. In this case, MRLs are just indicators of the violation or non-violation of Good Agricultural Practices (GAP), not an indication of health risk, (International Federation of Organic Agriculture Movements [IFOAM]) i.e legally defined "maximum residue limits" (MRL) are not a guarantee of "zero health risk". Therefore, risk exposure should evaluate based on toxicological end point such as, Acceptable Daily Intake (ADI) or Acute Reference Dose (ARfD) [30,31].

Conclusion

this study investigated the levels of pesticide residues in commonly used orange, guava and tomato. the results indicated that majority of the samples were contaminated with pesticide residues, with concentrations above the mrl. from a public health perspective, the observed levels of pesticide residues pose a potential health risk to consumers. to reduce this risk, sensitization of farmers to better pesticide safety practices and the need for continuous pesticide residue monitoring is highly recommended. on the other, the contribution to the adi shows that all the intakes of pesticide residues are still within acceptable limits. however, it should be emphasized that pesticide dietary intakes estimated in this study have only considered exposures from selected small group of fruits and did not include other food products or the rest of the fruits consumed by the study's participants.

Conflict of Interest

The authors have declared no conflict of interest

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Citation: *Holmes RS. Comparative structures and evolution of sterol-C5-desaturase (SC5D) genes and proteins: A major role in cholesterol biosynthesis. J Food Sci Nutr. 2022;5(1):101*