MONITORING OF PESTICIDE CONTAMNATION OF SELECTED LEGUMESAMPLES IMPORTED IN UAE

ABSTRACT

Sampling plans of 2375 selected legume imported into the UAE market has been examinedas part of an official surveillance program, these samples include beans, peas, peanuts, lupine and lentils, theywere collected from across United Arab Emirates (UAE) ports of entry during 2020 and 2021 by certified staff.These samples were analyzed by modified QuEChERS method for pesticide residue screening based on multi-reaction monitoring (MRM) mode with gas and/or liquid chromatography tandem mass spectrometry for monitoring 400 pesticides residues in these legume crops.The method used in this study was validated following the European Commission guidelines achieving good recovery values in the range 70–120% with relative standard deviation values lower than 20% and providing limits of quantification of the method in the low mg/kg range, in accordance with the maximum residue limits set by European policies and CODEX.

This monitoring program providea valuable source of information for estimating dietary exposure of UAE consumers to pesticide residues, and to check compliance with the national maximum residue levels in legume samples. The program was performed by the ministry of climate change and environment (MOCCAE)at UAE, hopping to provide the needed information on quantitative and qualitative pesticide residues.This monitoring study showed that the majority (98.8%) of legume crops samples analyzed had compliance with the legislation in force IN UAE and 29 samples (1.2%) contained residues above MRLs established by the Codex Committee on pesticide residues as well as by the European Union.

Keywords: Legumes, MRL, Monitoring, Multi residue, Pesticides, QuEChERS, UAE.

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1.INTRODUCTION

Legumes are plants that belong to the family, *Fabaceae* or *Leguminosae*, very diverse with nearly 20,000 species worldwide, Legumes come in a variety of shapes, colors, and sizes. They can be found in many formats including dried, canned, cooked, frozen, split, or ground into flour, these legume include beans, peas, peanuts, lentils, and lupines[1]. According to the FAO (2), a pulse is a type of legume that is exclusively harvested for the dry grain and therefore excludes peanuts and soybeans, which are harvested for their oil. Pulses are also sometimes referred to as grain legumes or pulse grains. The published literature often refers to the *Phaseolus vulgaris* species; these include kidney beans, haricot beans, pinto beans, and navy beans.

Legumeshas highly nutritious value and they are important sources of protein, carbohydrates, fats and dietary fiber, low glycemic index (GI)and can be consumed as food by human beings and animals [3]. They are thought to have unique health effects due to their high content of certain phytoestrogens such as isoflavones and other bioactive compounds(4).On account of their high nutritive value, they would play an important role in ensuring nutritional security especially for the developing countries [5].Thus, to ensure food safety and protect consumer health, international organizations such as the Codex Alimentarius Commission, established by the Food and Agriculture Organization of the United Nations (FAO) and the World Health Organization (WHO), and the European Union (EU), as well as many individual countries have established maximum residue limits (MRLs) to regulate pesticide residue levels in foods.

The contamination of legumes with pesticides in various parts of the world has been reported in scientific literature. Many of these literature highlight on the acute and chronic health risks that human beings may be exposed to as a result of the ingestion of legumes polluted with pesticides. Pesticides cause short-term health effects including hypersensitivity and mortality,some chronic untoward effects of pesticides are congenital disabilities and neurological damage as well as their persistence in the bionetwork [6].

As part of keeping imported food under constant control, the pesticide residue monitoring program, a compliance program, is used by the MOCCAE at UAE to monitor the level of pesticide residues in imported foods to ensure that they do not exceed the allowable limits (MRLs) according to UAE Mandatory Standard (UAE.S MRL1:2019) by cabinet resolution No.

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(4) In 2020, held on (2/1/2020). consideringthis monitoring study will help to generate residue data in establishment of national MRLs.The obtained results of monitoring the level of pesticide residues in imported legume crops consignments during 2020-2021 and comparing them with the maximum permissible limits of pesticide residues for the purpose of verifying compliance with national legislation is reported in this study.

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2. MATERIAL AND METHODS

Chemicals and standard solutions

Certified reference material (CRM) were purchased from DrEhrenstofer GmbH (Germany), with purity between 92.0 and 99.5%, LC-MS grade acetonitrile(Merk, Germany), methanol (LC-MS CHROMASOLV^{TM}, Ethyl acetate (LC-MS grade, Scharlab) (≥99.9%),Formic acid (Honeywell, Germany). Ready-made QuECHERS kits were purchased from Suplco; Supel™ QuE citrate extraction tube (contains 4.0 g $MgSO_4$, 1.0 g NaCL, 0.5 g NaCitrate dibasic sesquihydrate, 1.0 g NaCitrate tribasic dehydrate), Supel™ QuEPSA/C18 (EN) Tube, 15 mL clean up Tube (contains 150 mg Supelclean PSA, 150 mg Discovery DSC-18, 900.0 mg $MgSO_4$.) The solutions were prepared with Ultrapure demineralized water Milli-Q plus system (Merck-Millipore Corporations, USA).

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The monitoring program

2375 of legume samples included beans such asBeans (1170), Peas (165), peanuts (3), lupines (5) and Lentils (1032) were collected as a part of the national monitoring program for pesticide residues.The sampling was performed by authorized personnel across United Arab Emirates (UAE) ports of entry during 2020 and 2021. Samples were mainly taken according to sampling method outlined Codex guidelines to determine pesticide residues to comply with MRLs [7]. All samples barcoded with unique identification numbers, transported to the laboratory and stored at 4ºC until analyzed.

Analytical procedure

Extraction and clean-up of legume crops samples were carried out according QuEChERS method commonly used in the multi-residue analysis of food matrices [8] pesticide residues laboratory, Ministry of Climate Change and Environment, UAE with slight modifications. Each sample (approx. 50 g) was ground to powder, precisely 5.0 g of powder was weighed into a 50 mL Teflon capped centrifuge tube, 5.0 mL of Milli-Q water followed by 10 mL of acetonitrile was added, and the mixture was vigorously shaken for 1.0 min. to hydrate the sample. A mixture of 4.0 g MgSO4, 1.0 g NaCL, 0.5 g NaCitrate dibasic sesquihydrate, 1.0 g NaCitrate tribasic dehydrate were added to the extract in the tube, which was agitated for 3.0 min at 500 rpm on a shaker. The sample was centrifuged for 5.0 min at 3,000 rpm and the supernatant was collected. Samples required clean-up to remove any organic acids, polar pigments, and other compounds that could interfere with the analysis. For clean-up, 8.0 mL of the supernatant was pipetted into a 15 mL d-SPE tube packed with 150 mg Supelclean PSA, 150 mg Discovery DSC-18, 900.0 mg $MgSO_4$, the content of the tube was then vortex for 1 min, centrifuged for 5.0 min at 3000 rpm. Finally, for LC-MS/MS analysis, 1.0 mL of the supernatant was collected while GCMSMS analysis, 1.0 mL of supernatant was evaporated at 40 °C until dryness, replaced by ethyl acetate in auto sampler vial for analysis

Calibration curve:

Individual analytical stock solutions (1000 mg L^{-1}) for each pesticide were prepared considering the purity of each pesticide standard in methanol and ethyl acetate into a 10.0 mL calibrated volumetric flask and made up to 10.0 mL with methanol and ethyl acetate for LC and GC amenable pesticides, respectively and stored in the dark at −20°C. A standard mixed stock solution were prepared in methanol and ethyl acetate to 10 mg L^{-1}. Afterwards, a mixture with the concentration of 10.0 mg L^{-1} containing all pesticides was diluted to 1.0 mg L^{-1}. A stock solution of triphenyl phosphate (TPP) at concentration of 1.0 mg mL^{-1} was used as internal standard. Matrix-matched calibration was prepared using 5 concentration levels of 0.01, 0.02, 0.05, 0.1 and 0.2 mg kg^{-1}which were mixed with an ISTD solution and filled the volume with extracts from blank samples

Instrumental analysis

- **GC–MS/MS analysis**

GC–MS/MS analysis was performed using Agilent 7890A GC equipped with a 7693B. coupled to a Triple quadrupole (QQQ) mass spectrometer detector 7000 Series with electron impact ionization (EI) equipped with autosampler (Agilent Technologies, Santa Clara, CA, USA), MSD system (Agilent, USA). An Agilent Ultra Inert GC column, HP-5MSUI, was used to provide a highly inert flow path into the detector. The oven temperature was programmed from 70^{0}C (hold 3.0min) to 180^{0}C by a rate of 20^{0}C/min and finally increased to 300 ^{0}C (hold 2.5 min) by a rate of 5°C/min,the injection volume was 5.0 μL with splitless mode. Helium carrier gas (99.999%) flowed constantly at 0.5mL/min. The mass spectrometry detector (MSD) used electron impact ionization mode (ionization energy 70 eV). The temperature of ion source and quadrupole were set at 250^{0}C and 150^{0}C, respectively. The multiple reaction monitoring (MRM) mode with minimum two ions for each pesticide was used for detection and quantification of pesticides. The Agilent Mass Hunter Workstation software B.07.00SP2was used for data analysis.

- **LC–MS/MS analysis**

Detection and quantification were performed using QTRAP 5500® 5500 LC/MS/MS system (AB SCIEX, Foster City, CA, USA) equipped with an electrospray ionization (ESI) source working simultaneously in both positive and negative modes (ESI+ and ESI−). two ion transitions were selected for each compound, a quantifier and a qualifier MRM.In terms of chromatographic conditions, a column Luna® Omega 3 µm Polar C18 100 Å, LC Column 100 x 2.1 mm, Ea was used and kept at 40^{0}C, the autosampler was maintained at 10 ^{0}C to refrigerate the samples and a volume of 5 µL of sample extract was injected in the column. The mobile phase using 0.1% formic acid in ultrapure water as mobile phase [A] and formic acid 0.1% in methanol as mobile phase [B] with a flow rate of 0.5 mL/min.

Method validation and Acceptability Criteria

The acceptability of used method for the analysis of target pesticides was validated following the SANTE/2021/11312guidelines [9].Linearitywas determined using matrix-matched calibration curves with spiked blank samples at five concentrations (0.01, 0.02, 0.05, 0.1 and 0.2 mg kg^{-1}). All coefficients of determination (R^2> 0.99) were acceptable. Recoveries (%) and precisions, in terms of repeatability and reproducibility, were determined by analysis of blank samples spiked with standard solutions at two concentrations (0.01 and 0.1 mg kg^{-1}), with trueness or mean recovery (accuracy) in the range 70–120%. Precision was expressed as the relative standard deviation (RSD ≤20%) of replicate analyses

Quality Assurance:

The pesticide residues laboratory was audited as part of a laboratory quality assurance system by UKAS (United Kingdom Accreditation Service).and its accreditation status to the ISO/IEC 17025:2017 standard was confirmed and extended. The pesticides in the scope of the accreditation may be viewed on the United Kingdom Accreditation Service website at 2572Testing Multiple (ukas.com).

The method is applicable for determination of pesticide residues in legume samples with high starch and/or protein content and low water and fat content. 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 quantification started at 0.01mg/kg and up depending on the pesticide type and detection module. The measurement uncertainty expressed as expanded uncertainty and in terms of relative standard deviation (at 95 % confidence level) is lower than the default value set by the EU (± 50 %). Blank samples were fortified with the pesticides mixture and analyzed as a normal sample with each set of samples. The results were recorded on control charts. Repeated analysis of old samples was regularly carried out to control reproducibility.

Trueness Inter-Laboratory Comparison Proficiency Tests:

The method trueness was confirmed by participation in Inter-Laboratory comparison with Food Analysis Performance Assessment Scheme (FAPAS) at the Food and Environment Research Agency. Proficiency test were analyzed using the developed method. The z-scores were calculated by FAPAS laboratory using the spike level as true. In all cases z-score are below 2 and this met requirements of the organization. The result supported accuracy of the improved method forquantification of pesticides.

3. RESULTS AND DISCUSSION

The food supply is monitored to check compliance with national legislation for pesticide residues in food and ensure consumers are not being exposed to concentrations of pesticides that are harmful to their health. Unexpected residues can occur through deliberate misuse; the illegal use of allowed or banned pesticides; the use of sub-standard or counterfeit pesticide formulations; or contamination from various sources including spray drift from adjacent fields and transfer during storage and/or packing. The monitoring strategy consisting of the random sampling of food commodities; and an enforcement strategy involving the sampling of food commodities or specific sources where non-compliance with pesticide legislation was suspected or had been detected previously. The current monitoring pesticide residues from each shipment of legumes for any food safety risks and rejecting any unfit shipment for this purpose.

A total of 2375samples fromimported legumes in UAE were analyzed for pesticide residues during monitoring period for up to 400 pesticides, the pesticides to be examined were selected based on the list of registered agricultural pesticides authorized in the UAE and the list of prohibited compounds in the country, developed by the Ministry of Climate Change and Environment. Samples were analyzed for pesticide residues at national laboratories, ministry of climate change and environment (pesticide residues laboratory has continued to maintain and extend its accreditation status with the National Accreditation Body for the United Kingdom (UKAS)).

Method validation

As recommended by the European regulations (European Commission SANTE/2021/11312, the method validation is an essential prerequisite to provide accurate and reliable results during the official monitoring studies, the used method was validated under optimized conditions by determining the limits of detection (LOD) and quantitation (LOQ), the recovery and precision at different fortification levels. The recovery for all tested pesticides within the acceptable recovery range of 70–120% and the RSD of less than 10% considered acceptable and fulfill the criteria for quantitative methods (SANTE/2021/11312), [9]. These results indicate that the analytical method applied to this study is appropriate for the analysis of targeted pesticide residues legume crops.

Monitoring results in analyzed samples:

The objective of pesticide current monitoring programme is to ensure that imported legumes shipments comply with the maximum residue levels (MRLs) allowed under the mandatory UAE standard (UAE). S MRL1:2019), and in cases where a pesticide is not authorized to use or exceeds the permissible limit, tighten control over pesticides that are not allowed to be used or above the permissible limit rejecting any unfit shipments for this purpose. Moreover, the combination of monitoring data with food consumption data provides exposure estimate that can be used in toxicological appreciation.

The total 2375 selected and examined imported legume samples wereanalyzed within current monitoring programme. from2094 analyzed legume samples (88.16%), showed no detectable residues,while pesticide residues were detected in 281 samples (11.83%); the overall compliance with the legislation in force was 2346 samples (98.77 %). The29 samples (1.22%) contained residues above MRLs established by the Codex Committee on Pesticide Residues [10], as well as by the European Union[11] as shown in Table 1.

Table 1. Summary of Results of analyzed samplesduring monitoring program

Commodity	Sample Analyzed	Free Samples	Contaminated Samples		No. of Samples Within MRL		No. of Samples Above MRL	
			No.	%	No.	%	No.	%
Beans	1170	1081	89	7.6	78	66.67	11	0.94
Peas	165	30	135	81.81	119	72.12	16	9.69
Peanuts	3	2	1	33.33	1	33.33	0.0	0
Lupin	5	4	1	20	1	20	0.0	0
Lentils	1032	977	55	53.32	53	51.35	2	0.019
Total	2375	2094	281		252		29	
%		88.16		11.83		10.61		1.22

Out of 1170 beans samples analyzed, 7.60% were found contaminated with pesticide residues, and about 0.94% of the total contaminated samples contained pesticide residues above the maximum permissible limit, while the remaining 92.39% did not contain any pesticide residue.A percentage of 18.18% on 165peas samples showed no trace of residues and 72.12% had quantifiable pesticide levels, but lower than MRLs. A further percentage of 9.69% was associated with samples containing residues above MRLs.

The 1032 lentils samples analyzed showed, 94.67% to be compliant and associated with non-quantifiable residue levels. A percentage of 5.13% showed residue contents higher than the quantification limits but lower than the MRL; two samples contained pesticides at concentrations above MRLs.

The analyses performed on 3 samples of Peanuts showed a percentage of 66.66% for the residue-free samples, 33.33% with residues below the MRLs was detected in one peanut sample and no residues of the pesticides had detected higher residues than the corresponding MRLs.

According to pesticide residues observed in the lupine samples, 20% (1 out of 5 samples) containing pesticide residues below MRLs and no residues had detected higher residues than the corresponding MRLs laid down by CODEX and EU.Previous literature reveals that legumes are more susceptible to pest infestation; these are likely to be contaminated with certain chemical pesticides right from the crop growth to grain storage which may affect the food safety [12].legumes are usually stored for long periods in warehouses where various pesticides are intensively and successively applied many times resulting in their bioaccumulation. Many studies have shown that pesticide residues penetrate the grains and accumulate over time, thus indirectly exceeding the recommended doses. High amounts of organophosphorus pesticide residues were found in stored cowpea and two by-products [13], revealing a potential human dietary risk related to consumption of these grains.The most contaminated commodity was pea samples (9.69%) containing residues above MRLs. mainly chickpea which consider one of the widely consumed pulses in many countries. It is used in preparing a variety of snacks, sweets and condiments. Fresh green seeds are also consumed as green vegetable.

MRL Exceedances and Detection Frequencies of Pesticides in Analyzed Samples

The Exceedances detected pesticides, frequency and Status of registration for each crop analyzed under monitoring programs are presented in Table 2. The results revealed that 20 pesticides were detected in the analyzed legume samples above the permissible limits, referring to the number of pesticide residues detected exceed the permissible limits were black-eyed bean samples (6), Toor dal/yellow pigeon peas (5), Chickpeas (5), Chickpeas Black (3), Chickpeas White (2), Moong dal (2), while the following samples only one pesticides in each above th limit Chana Dal / Split Chickpeas, Matar Dal/ split peas, Yellow split peas, Soybean, Fava Beans, Moong whole, Green whole Lentils, Urad dal.As shown in table 2 in pea samples 15 different pesticides were detected, Chlorpyrifos wasthe most frequency (10) of total samples analyze and (3 out of 10) were detected above the permissible limits, followed by Fenpropathrin with the frequency (9) of total samples analyze which were at the same time above the permissible limits, Pirimiphos-Methyl with the frequency (3) of total samples analyze and (2 out of 3) were detected above the permissible limits, moreover, (6) samples contaminated with Acephate, Dimethoate, Myclobutanil, Phenthoate, Carbendazim and Thiophanate-methyl which were at the same time above the permissible limits, Malathion was monitoredwithin the limits of the permissible. Previous studies mentioned that, pesticide Chlorpyrifos is one of the world's most widely used organophosphorus pesticides for various applications including grain storage system. The use of chlorpyrifos has been restricted in UAE, US and some European countries but it is still in use in some developing countries. Also during a survey in National Capital Region (NCR) in 2009, it was found that chlorpyrifos is the most consumed pesticides [15].

Table 2. Summary of MRL Exceedances and Detection Frequencies of Pesticides in Analyzed Samples.

Commodity	No. of samples over MRLs	Pesticide Detected	Freq.	No. of pesticides over MRLs	*Status of registration
Toor dal/yellow pigeon peas	5	Fenpropathrin	4	4	Banned
		Pirimiphos-Methyl	2	1	Banned
		Chlorpyrifos	4	1	Restricted
Chickpeas	5	Acephate	1	1	Banned
		Acibenzolar-S-methyl	1		**Unregistered**
		Bitertanol	1	1	**Unregistered**
		Chlorpyrifos	3	1	Restricted
		Dimethoate	1	1	Banned
		Fenpropathrin	2	2	Banned
		Myclobutanil	1	1	Banned
		Pirimiphos-Methyl	1	1	Banned
		Thiamethoxam	1		Allowed
Chickpeas White	2	Chlorpyrifos	2	1	Restricted
		Phenthoate	1	1	Banned
		Fenpropathrin	1	1	Banned
Chickpeas Black	3	Chlorpyrifos	1		Restricted
		Fenpropathrin	1	1	Banned
		Malathion	1		Banned
Chana Dal /Split Chickpeas	1	Carbendazim	1	1	Banned
		Thiophanate-methyl	1	1	Banned
		Lufenuron	1	1	Allowed
Matar Dal/ split peas	1	Fenpropathrin	1	1	Banned
Yellow split peas	1	2-Phenylphenol	1	1	**Unregistered**
Black-eyed bean	6	Acetamiprid	1		Allowed
		Carbaryl	3	3	Banned
		Chlorpyrifos	2		Restricted
		Dimethoate	1		Banned
		Fenpropathrin	2	2	Banned
		Malathion	2		Banned
		Methomyl	1		Banned
Soybean	1	Imidacloprid	1		Restricted
		Propiconazole	1		Allowed
		Tebuconazole	1		Allowed
		Thiamethoxam	1	1	Allowed
		Tricyclazole	1	1	Banned
		Tridemorph	1	1	**Unregistered**
Fava Beans	1	Metalaxyl	1	1	Allowed
Moong whole	1	Indoxacarb	1	1	Allowed
Moong dal	2	Acetamiprid	1	1	Allowed
		Fluthiacet-methyl	1	1	Banned
Green whole Lentils	1	Chlorpyrifos	1		Restricted
		Fenpropathrin	1	1	Banned
Urad dal	1	Chlorpyrifos	1		Restricted
		Fenpropathrin	1	1	Banned
		Thiacloprid	1		Restricted

*Status of registrationaccording to List of registered pesticides in the Ministry (MOCCAE)-Last update 17 -11- 2021[14].

In all 1170 examined bean samples, 16 different pesticide residues were monitoredas shown in Table 2, Carbaryl wasthe most frequency (3) of total samples analyze which were at the same time above the permissible limits, followed by Fenpropathrin with the (2) of total samples analyze which were at the same time above the permissible limits, Acetamiprid detected with the frequency (2 samples) 1out 2 above the permissible limits. At the same time results mentioned that Fluthiacet-methyl, Indoxacarb, Metalaxyl, Thiamethoxam, Tricyclazole and Tridemorph all detected with the with the frequency (1 samples) and at the same at the time all above the permissible limits. On the other hand, 7 pesticides detected within the permissible limits each with the frequency (1 samples) as follows Chlorpyrifos, Malathion, Dimethoate, Methomyl, Propiconazole, Tebuconazole and Imidacloprid.With regard to pesticide residues observed in lentil samples (1032), the number of contaminated samples detected above the permissible limits was negligible, as only two samples contained pesticides above the permissible limits as mentioned (Table 1). Fenpropathrin was detected in both samples and at the same time all above the permissible limits, followed by Chlorpyrifos and Thiacloprid detected within the permissible limits.

Moreover, in beans samples (1170), five different pesticide residues were monitored, Tebuconazole, Indoxacarb, Metalaxyl Thiamethoxam and Acetamiprid are allowed / registered and authorized for use in accordance with UAE regulations of banned and restricted pesticides [Ministerial Decree No. 36 of 2018 on Banned and Restricted Pesticides in the United Arab Emirates] as mentioned in table 2. At the same time monitoring program detected residues of 7 banned pesticides mainly Carbaryl, Fenpropathrin, Fluthiacet-methyl, Tricyclazole, Malathion, Dimethoate and Methomyl according to UAE regulations of banned and restricted pesticides [Ministerial Decree No. 36 of 2018 on Banned and Restricted Pesticides in the United Arab Emirates].

Restricted pesticides Chlorpyrifos, Propiconazole and Imidacloprid were monitored all within the permissible limits.While, Tridemorph observed above the permissible limits, which is currently unregistered in the UAE regulations of banned and restricted pesticides [Ministerial Decree No. 36 of 2018 on Banned and Restricted Pesticides in the United Arab Emirates].

Same context in peas samples (165), observed 16 samples (9.690%) were contained pesticideresidues above the permissible limits. Nine banned pesticides residues according to Ministerial Decree No. 36 of 2018 on Banned and Restricted Pesticides in the United Arab

Emirates were detected Fenpropathrin, Pirimiphos- Methyl, Acephate, Dimethoate, Myclobutanil, Phenthoate, Carbendazim, Thiophanate-methyl and Malathion all above the permissible limits except Malathion within the limit. Only Chlorpyrifos, restricted for use in accordance with UAE regulations for banned and restricted pesticides, was observed in the total samples analyzed (10).

Referring to Table 2, Bitertanol and 2-Phenylphenol that are not registered for use in the UAE, were detected and all above the permissible limits. Except Lufenuron and Thiamethoxam weremonitored, which is currently authorized in the UAE regulations of banned and restricted pesticides [Ministerial Decree No. 36 of 2018 on Banned and Restricted Pesticides in the United Arab Emirates], Lufenuron was above the permissible limits.

In lentil samples (1032) contaminated detected samples was negligible (2), banned Fenpropathrinmonitored only in two samples withconcentration above the permissible limits, more over residues of restricted pesticides Chlorpyrifos and Thiacloprid were monitored with concentration within the allowable limit the permissible limits.These can be justified by lack of Good Agricultural Practices (GAP) leading to appropriate applications of pesticides by farmers, because of insufficient training and deficient assistance from agricultural extension agents, hence the necessity of actions to be taken by regulatory authorities to regulate usage of agrochemicals in the country.

Co-occurrence of Multiple Pesticide Residues

Multiple pesticide residues (up to sex in a single sample) were detected from analyzed legume samples, as shown in Table 3

Table 3. The number of analyzed samples, contaminated, having 1, 2 and more than two pesticides

Commodity	Sample Analyzed	Contaminated Samples	No. of samples with one pesticide		No. of samples with two pesticides		No. of samples with more than two pesticides	
			No.	%	No.	%	No.	%
Beans	1170	89	65	73.03	13	14.60	11	12.35
Peas	165	135	108	80.0	20	14.81	7	5.18
Peanuts	3	1	0.0	0.0	1	33.33	0.0	0.0
Lupin	5	1	0.0	0.0	1	20.0	0.0	0.0
Lentils	1032	55	43	78.18	6	10.9	6	10.90

Total	2375	281	216	41	24
%		11.83	76.86	14.59	8.18

In bean samples,73.03% (65) of the analyzed samples contained residues of one insecticide while two pesticides were detected in 14.60% (13) of samples and 12.35% (11) contained three or more different types of pesticide residues, Additionally, beanswere the crop with highest number of samples with multiple residues, compared with peas and lentils. The multiple residues were found mostfrequently in soybean and black-eyed bean) have contamination of more than two pesticide residues including Acetamiprid, Carbaryl, Chlorpyrifos, Dimethoate, Fenpropathrin, Imidacloprid, Profenofos, Propiconazole, Tebuconazole, Thiamethoxam, Tricyclazole and Tridemorph indicating the co-occurrence of multiple pesticide residues in beansamples. Similar results have been detected in lentils10.90% (6) samples contained 6 different pesticides including Chlorpyrifos, Thiamethoxam, Tolclofos-methyl, Deltamethrin, Imidacloprid and Piperonyl butoxide. The occurrence of multi-residue pesticide contamination in different commodities has also been reported in other investigations [16, 17, 18] mentioned occurrence of multiple residues is likely to be a consequence of the application of different types of pesticides to protect a crop against different insect pests and diseases, where the incidence of pests can be extremely high. Consequently, a follow-up investigation is needed to determine risk assessment for multiple residues.

4. CONCLUSION

This monitoring program quantified the amount pesticide residues in imported some legume crops, which indicated that regulation of pesticide maximum residue limits (MRLs) fully enforced in UAE. Risks were mainly associated with the residues of pesticides. Due to multiple pesticide residues exceeding the MRLs for single residue concentrations, the consumers are exposed to pesticides.

Data obtained from this monitoring program is considered important source of information for estimating the potential health risks associated with the exposures to these pesticides' contaminantssince it is based on fully validated and accredited analytical procedures, and it provides accurate data related to 2375 samples of widely consumed legume types.

The results from this monitoring program, are a valuable source of information for estimating dietary exposure of UAE consumers to pesticide residues and to contribute to the knowledge of food pesticide contamination. Moreover, it is providing information that makes it possible to take the appropriate measures to reduce health risk potential.

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