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EXPOSURE ASSESSMENT TO PESTICIDE RESIDUES AND TRACE METALS RELATED TO THE CONSUMPTION OF IMPORTED ONIONS (*Allium cepa*) IN SENEGAL

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ABSTRACT

In Senegal, the onion is one of the most consumed vegetables because it is used in all salty culinary preparations. The objective of the study was to assess the contribution of imported onions to exposure to pesticide residues and metallic trace elements. Composite samples of onions were taken in the seven largest markets of Dakar: Thiaroye, Keur Massar, Castors, Cambérene, Rufisque, Tilène and Dalifort. The metallic trace elements were determined by the ICP-AES, type Agilent Technology serial number AU 14110053 of 2014, while pesticide residues were detected and quantified by gas chromatograph, type Agilent Technology 6890A serial CN10721019, equipped with an Electron Capture micro-Detector with serial number 022423. The average content of the composite samples in lead (Pb) (778.22 µg/kg) was 7 to 8 times higher, in cadmium (Cd) (12.43 µg/kg) 5 times lower than the maximum residue limits determined by the European Union and the Codex Alimentarius, while the average concentration of aluminum (Al) was 13570 µg/kg. Twenty four (24) pesticide residues were tested. The average concentrations of some pesticides banned in European Union (EU) exceeded the maximum limits set by them. In fact, they are more than hundred (100) times higher for Prophenophos (2088.16 µg/kg), 25 times for Fenthion (508.01 ppb), 7 times for Tetramethrin (72.56 µg/kg), 2.5 times for Parathion methyl (50.16 ppb), 2 times for Dichlorvos (19.12 µg/kg), and 1.4 times for Endrin (14.26 µg/kg). The Dimetoate and the Malathion, although 21224 authorized, were found in onions at concentrations 25 times (250.8 µg/kg) and 2 times (40.71 µg/kg), respectively higher than the maximum limits set by the EU. Only the average content of Chlorpyrophos (4.13 µg/kg), Bifenthrin (2.99 µg/kg), Lambda Cyhalothrin (7.30 µg/kg) and Cypermethrin (8.095 ppb) were in accordance with the EU regulations. The results of the exposure assessment reveals that the calculated daily consumption of 0.158 kg of these onion samples by a 60 kg average body weight Senegalese adult would provide 56% of the Toxicological Reference Value for lead, 25% for aluminum, 66% for Dimetoate, 63% for Dichlorvos, 28% for Dieldrin, 19% for Fenthion, 18% for Endrin and Prophenophos and 13% for Parathion-methyl. This study reveals that the imported onion contributes to the exposure of the Senegalese adult to eight (8) phytosanitary active substances and three (3) metallic trace elements. Thus, the health risk cannot be ruled out and it is important to set up a monitoring plan for the imported onion.

Key words: Metallic trace elements, pesticide residues, exposure, onions, Senegal

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INTRODUCTION

Foodborne diseases are a significant cause of morbidity. Millions of people become ill and a large number of them die after ingesting food that is unfit for human consumption [1]. This highlights the importance of implementing a system to ensure that ingested food is not contaminated, among other things, with toxins and toxic chemicals. This contamination can occur at any stage of the food chain, from the farm to the table. One of the main routes of exposure of agricultural products to harmful substances is when they enter, settle and accumulate on the crop plants [2].

Among the harmful substances in foods that can affect the consumers' health, there are two important types:

- Metallic Trace Elements (MTEs), such as heavy metals which have a very long persistence time and generally have a bio-accumulative character [3], found in fertilizers.
- Residues of plant protection products (such as herbicides) that are applied on the plants.

With the idea of protecting the consumers, authoritative international bodies have decreed quantitative limit values above which the consumer's health can be affected. These Toxicological Reference Values (TRVs) associated with contamination and consumption data, make possible the evaluation of sanitary risks associated with consumption of a given food.

In Senegal, onions (Allium cepa) are one of the most commonly consumed agricultural products. In fact, it is used in all the salty culinary preparations of Senegalese people. This means that it is consumed at least 12 times, corresponding to 1.55 kg per week [4]. Its production at the local level has increased significantly and is supported by the implementation of measures that protect the local market [5, 6].

Onion producers globally use intensive agricultural practices as well as new farming techniques in order to meet the demand and increase the yield of their production. In these agricultural practices, one can assess the crop protection measures through the common use of plant protection products [7]. The products are used intensively that the level of world pesticide production is estimated at 4.15 million tonnes in 2018 according to data provided by the Food and Agriculture Organization Corporate Statistical Database [8].

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In addition to plant protection products, the use of fertilizers to enrich the soils with essential nutrient elements can be dangerous. This is because the fertilizers may contain traces of heavy metals, which by cumulative effect, pollute the soil, contaminate agricultural products and irrigation water [7, 9, 10, 11]. Like all food chains, the imported onion chain also involves sanitary risks that should be assessed because of the high onion consumption level in Senegal [5].

This study was conducted to evaluate the exposure of the Senegalese population to pesticide residues and Metallic Trace Elements that could occur through imported onions consumption. Thus, the contamination level of different varieties of imported onions by Metallic Trace Elements and by pesticide residues were determined. These data were then combined with food consumption data from published survey reports [4, 12, 13] in Senegal in order to assess exposure based on toxicological data.

MATERIALS AND METHODS

The equipment consisted mainly of glassware and conventional laboratory consumables. To quantify the pesticide residues, the gas chromatograph equipped with a micro-electron capture detector serial number 022423, type Agilent Technology 6890A serial CN10721019 was used. As for, the trace metallic elements were quantified with the inductively coupled plasma atomic emission spectrophotometer called ICP-AES, type Agilent Technology serial number AU 14110053 of 2014.

All the reagents used were of analytical quality.

This study covered only the two varieties of imported onions that were available on the market during the study period and named 1 and 2. Ultimately, 27 substances were tested:

- 3 Metallic Trace Elements: lead (Pb), cadmium (Cd) and aluminum (Al)
- 24 pesticides, 6 of which are classified as priorities in terms of monitoring under a national plan for monitoring pesticide residues in fruit and vegetables in Senegal. These are Dicofol, Dimetoate, Bifenthrin, Cypermethrin, Lambda cyhalothrin and Trifluralin.

Individual onion consumption is estimated on the basis of national statistical data [12]. Indeed, in 2016 the national production of onions was estimated at 393.225 tons and imports at 151.205 tons for a Senegalese population of 14.799.859 [13].

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Thus, the annual average consumption (AAC) of a Senegalese is estimated according to the following formula [14]:

$$\mathrm{AACestimated/year} = ((\mathrm{Production} + \mathrm{Importation}) - \mathrm{Exportation})/\mathrm{Population}$$

The review of vegetables consumption survey report of Pikine Guédiawaye » (VCSR) [4] enabled an estimation of the amount of onions consumed by a Senegalese, particularly in Pikine and Guédiawaye areas of Senegal. To get as close as possible to reality, these two data were averaged to determine the average amount of onions consumed each year (y) (AAOC) by a Senegalese.

$$\text{Average amount ofonions consumed}(\mathrm{g/y}) = (\mathrm{AAC}\left(\frac{\mathrm{g}}{\mathrm{y}}\right) + \mathrm{VCSR}\left(\frac{\mathrm{g}}{\mathrm{y}}\right))/2$$

A review of most visited markets by Dakar citizens [15] enabled to choose the following locations: Thiaroye, Keur Massar, Castors, Cambérene, Rufisque, Tilène and Dalifort as sampling sites. At the time of the study, only Dutch red onion and Dutch yellow onion varieties were available in these markets. The sampling was carried out in accordance with the methods recommended by Codex [16].

Preparation of the samples (of imported onions) for analysis

Each composite sample of 3kg was peeled, chopped, crushed using a Blixer 6 food processor blender then homogenized before being divided into three 1kg portions. These samples were then frozen at -20°C pending analysis.

Determination of metallic trace elements in imported onions into Senegal

Mineralization was carried out according to the perfectly mastered and validated procedure of ODLAB (supplier of the mineralization device). In a Teflon tube, 1g of perfectly crushed onion was put, then 15ml of concentrated nitric acid, 3ml concentrated hydrochloric acid and 0.5 ml of perchloric acid were added. The whole is preserved in ambient temperature for a night before being put in the GF-Sample Digestion System ODLAB (equipped with a temperature programmer) for mineralization. After cooling down, the mineralized sample was transferred to a 50ml volumetric flask and adjusted to the mark with bi-distilled water (ODLAB).

The measures were completed using an Agilent Technologies 4200 Microwave Plasma Atomic Emission Spectroscopy. The reading wavelengths of Cd 228.802nm, Pb 405.781nm and Al 396.152 nm. Quantification was performed using the calibration lines established with five standard solutions of 0.05ppm,

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0.1ppm, 0.2ppm, 0.5ppm and 1ppm prepared from 200ppm stock solution of lead, cadmium, aluminum.

The concentration of Metallic Trace Elements in µg/kg was expressed through the following classic formula:

$$\mathrm{C}(\mu\mathrm{g/kg}) = (\mathrm{Cread.Vd(ml)})/\mathrm{T}$$

Cread: concentration read on the spectrophotometer
TP: Test Portion
Vd: Dilution volume

Pesticide residues analysis of imported onions into Senegal
Pesticides residues were analyzed using the modular multi-residue method of QUECHERS NF EN 15662 [17]. Pesticides quantification was performed using the calibration lines established with five (5) daughter standard solutions of 0.05mg/kg, 0.1 mg/kg, 0.2 mg/kg, 0.5 mg/kg and 1 mg/kg prepared from 200 mg/kg stock solutions of the active substance considered. The quality of the analytical process was checked by the addition of an internal standard at the time of extraction and on reading on the Gas Chromatography (GC). Polychlobiphenyl 28 (PCB 28) was used as an internal standard at a concentration of 0.5mg/kg. If the extraction is carried out in optimal conditions, the PCB recovery rate must be between 70 and 110%.

Exposure *scenario* of imported onions into Senegal
The exposure *scenario* involves individual of 60 kg of body weight (b.w), consuming an average amount (AAOC) of 0.158 kg of imported onions per day for his or her lifetime. Also, only the exposure from imported onion consumption is considered. Exposure was assessed by estimating the Daily Intake Rate (DIR) compared to the most recent Toxicological Reference Values (TRVs).

Exposure assessment of imported onions into Senegal
Exposure assessment were estimate when the average levels of Pb, Cd, Al and phytosanitary active substances in inions imported exceeded the maximum allowed residue limits. Thus, the estimate daily ingested dose (EDI) is given by the following formula

$$\mathrm{EDI} = \frac{\mathrm{Conc\ of\ element\ considered}(\frac{\mathrm{mg}}{\mathrm{kg}})\ \mathrm{x\ Daily\ consumption}(\frac{\mathrm{kg}}{\mathrm{day}})}{\mathrm{Body\ weight(kg)}} \quad [18]$$

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The imported onions' contribution to exposure to contaminants is the ratio of the EDI to the toxicological reference value (TRV) multiplied by 100.

RESULTS AND DISCUSSION

Levels of metallic trace elements in onions imported into Senegal

Lead (Pb), cadmium (Cd) and aluminum (Al) contents in different analyzed samples are given below in Table 1.

Table 1 shows that all nine composite samples of imported onions taken from different markets had lead levels of 778.22 µg/kg that were 7 to 8 times higher than the Maximum Limit of 100 µg/kg in onions as recommended by Codex in 2018 [19] and the EU in 2006 [20]. An explanation for the lead contamination level found may be that the contamination levels in Danish agricultural soils (country of origin) are in the median concentration ranges from 500mg/kg dry soil to 12000mg/kg dry soil [21]. In addition, according to the WHO Regional Office for Europe, increasing lead concentration in soil enhances the uptake of lead accumulated by the roots over decades [22]. In Ghana, the highest soil Pb (36.1 mgkg-1 Pb) was recorded at dumpsites Kamusi Metropolis [23].

Table 1 also shows that five of the nine samples had cadmium levels lower than the Maximum Limits of 50 µg/kg onions set by Codex and the EU [19, 20]. In fact, the average Cadmium concentration of the imported onion composite samples taken in the Dakar markets was equal to 12.43 µg/kg. This Cd average concentration is close to that found in the onions consumed in Denmark, which is 11.8 µg/kg [24]. The low level of cadmium found in the samples can be explained by the low contamination of Danish soils. Indeed, the maximum median concentration of cadmium found in Danish soils is 180 µg/kg [25]. On the other hand, in Ghana, the highest concentration of Cd in the soil (36.1 mg/kg) was recorded in the dumpsite of Kamusi Metropolis [23]. Onions are one of products which may, upon the request of the importers or exporters, be subject to control by phytosanitary inspectors.

Aluminum still has no Maximum Residue Limits (MRL) in food which includes onions, however, there is a maximum residue limit for water at 200 µg/L [26]. The average concentration of aluminum in the study onions was 13570.43 µg/kg.
The average concentration of lead (778.22 µg/kg), cadmium (12.43 µg/kg) and aluminum (13570.43 µg/kg) in the sampled onions were higher than those found in the onion samples taken in Benin, Cameroon, Mali, Nigeria [27]. This difference can be explained by the fact that in their case, the onion samples were prepared

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"as consumed" before analysis. Indeed, during cooking, the level of heavy metals can decrease by entrainment by water vapor during boiling or by oil during frying. [28]. However, lead and cadmium levels in the study samples are lower than those grown in Nigeria and irrigated with industrial wastewater. This can be explained by the fact that the heavy metals contained in the effluents used for the irrigation of crops can penetrate into food [29]. The same trend is seen with onions grown in Aliero, Nigeria. Indeed, they contain average lead concentrations of 4560 µg/kg and cadmium of 240 µg/kg. [30]. There are no data that that can be used to compare the Pb, Cd, Al composition of onions grown in Senegal.

Occurrence of pesticides in onions imported into Senegal

Quantity of pesticides found in samples of imported onions from different markets of Dakar Senegal. Tables 2 and 3 show the average concentration of compliant and non-compliant pesticide residues, respectively, in the imported onion samples taken from different markets in Dakar.

Table 4 provides the average concentrations of various pesticides found, Maximum Residue Limits (MRLs) authorized by the European Union, the Codex Alimentarius and each pesticide's status at the European level [31, 32]. On each of the samples of imported onions taken from the different markets in Dakar, the 24 active phytosanitary substances were tested. No pesticide residues were detected (ND) in the Tilene 1 sample. These findings have not been reported before.

Pirimiphos-methyl, fenitrothion and dicofol were found in 88% of the samples but could not be quantified, meaning that the amounts present were below the limits of quantification. The same applies to deltamethrin, which could only be quantified in the sample of Camberene 1, at a concentration of 15.44 µg/kg, which was below the maximum limit set by the EU.

As for endosulfan, it was present in 8 samples out of 9 tested. However, only the samples of Thiaroye 1 (2.68µg/kg), Camberene 2 (3.39µg/kg) and Dalifort 2 (2.22µg/kg) could be quantified. Moreover, the values found are in compliance with the standards. It can be concluded that pirimiphos-methyl, fenitrothion, dicofol, deltamethrin and endosulfan were present in onion samples at a concentration corresponding to their Limit of Quantification (LOQ), under the high assumption [33]. Lindane, dieldrin, endrin and dichlorodiphenyltrichloroethane (DDT) are persistent organic pollutants, listed in the Stockholm Convention. Their use is prohibited and only DDT can still be used and produced for vector control. They were present in all samples at average levels of 2.38µg/kg, 10.77µg/kg,

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14.26µg/kg, 36.68µg/kg, respectively. As a result, the quantities found for Lindane and DDT were below the limits authorized by the European Union.

Four samples out of the nine analysed had dieldrin concentrations below the standard. These include Castors 1 (5.89µg/kg), Camberene 1 (9.89µg/kg), Dalifort 1 (5.97µg/kg) and Camberene 2 (7.64µg/kg). However, the quantities present in Rufisque 1 (14.81µg/kg), Keur Massar 1 (13.22µg/kg), Thiaroye 1(14.22µg/kg) and Dalifort 2 (13.64µg/kg) were about 1.4 times higher than the standard.

Endrin was detected but not quantified in samples 1 and 2 of Dalifort but also in Camberene 2. It was present in the samples of Castors 1 (5.82µg/kg) and Camberene 1 (8.30µg/kg) at acceptable compliance levels. Endrin was present only in Rufisque 1 (16.96µg/kg) and Keur Massar 1 (17 µg/kg) at levels approximately 1.7 times higher than the standards. The French Total Diet Study 2 revealed average estimated levels of dieldrin ranging between 0.003 mg/kg (dairy products, meat, poultry, charcuterie, offal and seafood) and 0.015 mg/kg (chocolate and drinks). For DDT, endrin and lindane no residues were detected in the vegetable samples [34].

Among the pesticides not authorized by the EU Database pesticides 2019 [32], trifluralin as well as permethrin and fenvalerate were present in all samples at acceptable levels, with mean values of 3.92µg/kg, 26.47µg/kg and 2.34µg/kg, respectively. Unlike dichlorvos, which was present at an average concentration of 19.12 µg/kg that corresponds to 1.9 times the standard, malathion (43.71µg/kg), parathion-methyl (49.23µg/kg), tetramethrin (72.56µg/kg), fenthion (508.01µg/kg) and profenophos (2088.16 µg/kg) were present at levels 2.18 times, 2.5 times, 7.25 times, 25.4 times and 104.41 times, respectively, higher than their respective standards (UE database, 2019) [32]. In the study of total sub-Saharan diet, only profenofos and permethrin were found in onion samples from Douala at average concentrations of 0.1 µg/kg and 6 µg/kg respectively [35].

European Union authorized pesticides such as Lambda cyhalothrin (7.30µg/kg), Cypermethrin (8.09µg/kg), Esfenvalerate (7.55µg/kg), Chlorpyrifos ethyl (4.38µg/kg), Bifenthrin (2.99µg/kg) which were present at levels in accordance with the standard, contrary to Dimetoate (250.09µg/kg) which was found at a level 25 times higher than the maximum limit.

Some of these residues were also quantified in the sub-Saharan Total Diet Study vegetable samples: Dichlorvos (5.1 to 5. 4 µg/kg); Prophenophos (0.0 to 0.4 µg/kg); Chlorpyrifos (1.1 to 1.3 µg/kg), Cypermethrin (0.9 to 1.1 µg/kg), Lambda

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Cyhalothrin (0.7 to 1.0 µg/kg), Permethrin (20.2 to 20.5 µg/kg) [34]. Lead, cadmium and aluminum exposure estimations for a Senegalese adult consuming of imported onions into Senegal

Table 5 illustrates that a Senegalese adult would ingest 0.014 mg Pb/kg body weight/day from imported onion. Thus, the contribution of onion samples imported into Senegal to lead exposure is 56% of the Provisional Tolerable Weekly Intake (PTWI) [36]. This contributes 3 times lower than the Daily cadmium intake estimated for French adult to 10% of the PTWI [36]. Table 5 shows an Ingested Daily Intake of aluminum of 0.036 mg/kg body weight/day. Therefore, dietary exposure to aluminum through onion consumption represents 25.2% of the PTWI estimated by JECFA, in 1989 to 1mg/kg body weight. This is higher than the value found in the study of the total diet of the French population where the vegetables group contributes 15 to 20% of equivalent PTWI [36].

Exposure to pesticide residues of imported onions into Senegal

The Daily Intake Rate and the contribution of the residue corresponding to the percentage of the Acceptable Daily Intake are calculated only for pesticides whose levels do not comply with the established standards. Table 6 indicates that the daily consumption of 0.158kg of these onion samples brings to the Senegalese adult of 60kg a percentage of the ADI of 66% for dimetoate, 63% for dichlorvos, 28% for dieldrin, 19% for fenthion, 18% for endrin and profenofos and 13% for Parathion-methyl.

The study of the total diet of the French population, the legumes group contribution to percentage of the ADI was lower, 2 to 7.9% for dimetoate, 0 to 20.2% for dichlorvos, 5.6% for dieldrin, 10.4% for fenthion, but was higher, 21.9% for endrin and 15.8% for parathion-methyl [34]. The study of human dietary exposure to chemicals in sub-Saharan Africa revealed a dietary exposure to chlorpyrifos exceeded the PTWI in 62% of households in Bamako [38]. Daily Intake Rates are estimated only for pesticide residues in excess of established maximum limits. In USA, all estimated exposures to the 77 pesticides for the general US population were well below chronic reference dose (RfD) levels. Only 3 of the 77 pesticides showed exposures greater than 1 % of chronic RfDs [39].

CONCLUSION

Of the 24 phytosanitary active substances quantified in the samples of onions imported into Senegal, 15 are not authorized in the EU and 11 are at levels that do not comply with the recommended maximum limits.

This study reveals that the contribution of onions imported to Senegal to exposure to Pb, dimetoate and dichlorvos is greater than 50% of their ADI. The risk for the Senegalese of being exposed to levels above the Toxicological Reference Values is not zero, as the onion is used in all salty culinary preparations with other ingredients which could contain the same residues.

The authorities have the responsibility to ensure that chemicals are not present in the diet of Senegalese at levels likely to harm their health. But its resources being limited, prioritization is necessary. This study provides scientific information on the strong contribution of onions to exposure to several substances. Thus, risk management actions must be pursued in order to reduce the levels of these contaminants in imported onions.

Dimetoate, dichlorvos and lead should be classified as priority substances in terms of monitoring. Dieldrin and endrin are POPs, still present at levels above the EU standard. They need to be monitored to ensure compliance with the fixed EMRLs. This study should be extended to other contributing foods to exposure to the substances found. This would make it possible to refine the assessment of the total exposure of the Senegalese population to Metal Trace Elements and pesticide residues.

Disclaimer
The views expressed in this publication are only those of the authors.
Credit authorship contribution statement

Sokhna NDAO DIAO: Investigation, Writing - original draft. Marie NDAO SARR: Investigation, Writing. Ismaïla DIOP: Investigation. Cheikhouna Oumar LY: Investigation. Amadou DIOP: Validation. Bara NDIAYE: Validation. Yérim Mb. DIOP: Validation. Serigne Omar SARR: Conceptualisation, Supervision, Writing - review & editing.

Declaration of Competing Interest
The authors declare that there is no conflict of interest.

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Table 1: Pb, Cd and Al Concentrations (µg/kg) of different imported onions samples taken from different markets in Dakar with the standards in force (maximum residue limits) by Codex [19]; EU [20]

Sample	Lead (µg/kg)	Cadmium (µg/kg)	Aluminum (µg/kg)
Tilène1	726.90 ± 7.46	-	11251.75 ± 0.88
Castor 1	786.69 ± 11.55	-	11632.94 ± 2.85
Cambérène1	800.29 ± 31.12	-	10195.21 ± 1.04
Rufisque 1	761.17 ± 2.11	-	37167.68 ± 0.47
KeurMassar 1	813.46 ± 22.49	15.53 ± 0.012	9131.59 ± 1.05
Dalifort 1	807.10 ± 16.04	11.70 ± 0.06	11742.03 ± 2.02
Thiaroye1	827.33 ± 15.53	6.90± 0.05	10312.81 ± 0.75
Cambérène 2	728.34 ± 10.16	15.60 ± 0.05	9699.38 ± 0.42
Dalifort 2	752.71 ± 8.42	12.41 ± 0.05	11023.89 ± 1,31
Mean	778.22 ± 37.26	12.43 ± 3.56	13570.00± 8.89
Standard Codex / UE	100	50	-

(-): none detected

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Table 2: Average concentration of compliant pesticide residues in the imported onion samples taken from different markets in Dakar

Pesticides (µg/kg)	Castors 1	Cambérene1	Rufisque 1	Keur Massar1	Dalifort 1	Thiaroye1	Cambérene2	Dalifort 2	Average concentration (µg/kg)
Trifluralin	1.76	3.2	4.37	4.42	3.68	4.22	4.42	4.82	3.86 ± 0.92
Lindane	0.78	2.28	2.82	2.79	2.52	2.39	2.79	2.67	2.38 ± 0.63
Chlorpyriphos Ethyl	2.39	6.1	3.12	4.42	1.61	6.37	5.16	5.86	4.38 ± 1.69
DDT	12.86	37.12	35.06	39.77	60.59	30.07	4.57	32.87	36.68 ± 13.57
Endosulfan	NQ	NQ	NQ	NQ	NQ	2.68	3.39	2.22	2.76 ± 0.48
Bifenthrine	1.19	2.58	3.4	3.71	3.27	3.46	3.39	2.95	2.99 ± 0.75
Lambda Cyhalothrin	6.06	7.08	6.13	10.52	7.12	12.88	5.31	3.33	7.30 ± 2.80
Permethrin	9.37	27.21	30.26	31.95	28.32	30.49	28.78	25.37	26.47 ± 6.74
Cypermethrin	2.46	6.47	9.79	10.78	11.19	75	6,52	10,05	8,09 ± 2,75
Fenvalerate	0.72	2.49	2.39	2.89	2.63	2.67	2.97	1.96	2.34 ± 0.67
Esfenvalerate	2.55	8.23	8.86	10.29	7.53	9.33	7.66	5.96	7.55 ± 2.55
Deltamethrin	NQ	15.44	NQ	NQ	NQ	NQ	NQ	NQ	15.44

ND: Non Detected
NQ: Non Quantified

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Table 3: Average concentration of non-compliant pesticide residues in imported onion samples taken from different markets in Dakar

Pesticides (µg/kg)	Castors 1	Cambérene 1	Rufisque 1	KeurMassar 1	Dalifort 1	Thiaroye 1	Cambérene 2	Dalifort 2	Average concentration (µg/kg)
Dichlorvos	9.08	17.24	23.04	22.62	19.9	19.2	21.5	20.41	19.12 ± 4.18
Dimetoate	108.72	240.38	284.22	290.89	253.97	275.35	299.58	247.6	250.09 ± 57.03
Parathion methyl	20.19	57.71	61.38	53.97	43.95	44.82	57.71	69.08	51.10 ± 14.01
Malathion	ND	39.21	41.56	ND	30.78	39.57	71.29	39.84	43.71 ± 12.81
Profenofos	1213.09	2567.78	2388.99	2791.78	1473.71	2922.61	1096.61	2250.78	2088.16 ± 676.83
Fenthion	331.81	458.91	529.42	640.76	489.38	686.55	492.04	435.22	508.011 ± 105.66
Dieldrin	5.89	9.89	14.81	13.22	5.97	14.22	7.64	13.64	10.77 ± 3.76
Endrine	5.82	8.30	16.96	17	ND	17.28	ND	ND	14.26 ± 4.87
Tetramethrin	25.18	98.71	72.4	83.37	80.68	75.66	85.39	59.14	72.56 ± 20.81

ND: Non Detected

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Table 4: Presentation of sample average concentrations, Codex [31] and European Union maximum limits as well as their status in EU [32]

PESTICIDES	Average concentration(µg/kg)	Codex MLR (µg/kg)	EU MLR (µg/kg)	EU status
Dichlorvos	19.12 ± 4.18	-	10	NA
Trifluralin	3.86 ± 0.92		10	NA
Lindane	2.38 ± 0.63		10	NA
Dimethoate	250.09 ± 57.03	50	10	A
Parathion methyl	51.10 ± 14.01		10	NA
Pirimiphos methyl	-	200	10	A
Chlorpyriphos ethyl	4.38 ± 1.69	200	20	A
Malathion	43.71 ± 12.81	1000	20	A
Fenitrothion	-	50	20	NA
Prophenophos	2088.16 ± 676.83		50	NA
Dicofol	-	-	20	NA
Fenthion	508.01 ± 105.66	-	10	NA
Dieldrin	10.77 ± 3.76		10	NA
Endrine	14.26 ± 4.87	50	50	NA
DDT	36.68 ± 13.57		100	NA
Endosulfan	2.76 ± 0.48	200	10	NA
Bifenthrine	2.99 ± 0.75	-	10	A
Tetramethrin	72.56 ± 20.81		20	NA
Lambda cyhalothrine	7.30 ± 2.80	200	50	A
Permethrin	26.47 ± 6.74	10	100	NA
Cypermethrin	8.09 ± 2.75	10	20	A
Fenvalerate	2.34 ± 0.67	-	20	NA
Esfenvalerate	7.55 ± 2.55	50	50	A
Deltamethrin	15.44	50		A

A: Authorised
NA: Unauthorised

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Table 5: Daily intake rate for Pb, Cd and Al in analysed onion samples and contribution to dietary exposure compared to TRVs EFSA, [40] and CCCF [36]

Contaminants	Daily intake rate (mg/kg b.w./d	Weekly intake rate «DHI » (mg /kg b.w. /week)	PTWI (mg / kg b.w. / week	Contribution % TRV
Lead	0.002	0.014	0.025	56
Cadmium	0.00003	0.00021	0.0025	8.4
Aluminium	0.036	0.252	1	25.2

EFSA: European Food Safety Authority
CCCF: Codex Committee on Contaminants in Foods

Table 6: Estimation results of Daily Intake Rates for each non-compliant pesticide and their contribution in relation to the Acceptable Daily Intake (ADI)

PESTICIDES	EDI(mg/kg b.w./day)	ADI (mg/kg b.w/day)	Contribution %ADI
Dichlorvos	0.00005	0.00008	62.95
Dimethoat	0.00066	0.001	65.86
Parathion methyl	0.00013	0.001	13.46
Malathion	0.0001	0.03	0.38
Profenofos	0.0055	0.03	18.33
Fenthion	0.0013	0.007	19.11
Dieldrin	0.00003	0.0001	28.36
Endrine	0.00004	0.0002	18.78
Tetramethrin	0.00019	0.02	0.95

EDI: Estimate Daily Intake Rate
ADI: Acceptable Daily Intake
b.w. = body weight

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