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Research Article

Residues of Some of the Commonly Used Insecticides on Snake Cucumber (*Cucumis melo* L., var. *flexuosus*) Grown in Khartoum State, Sudan

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Abstract

This study was carried out to evaluate the residue level of some of the commonly used insecticides in snake cucumber grown or sold in Khartoum State, Sudan as well as to assess farmer's knowledge about safe use of pesticides in the study areas. Random samples of snake cucumber fruits were collected from four locations in Khartoum; two vegetable markets (Khartoum North and Khartoum) and two vegetables farms (South Khartoum (Jebel Aulia) and west Omdurman areas). Simple questioner was distributed to farmers in these areas. Collected samples were extracted according to official methods and analyzed by GC-FID for insecticide residues. Results indicated the presence of 7 pesticides in snake cucumber grown in Khartoum State at both farms and market levels. Detected pesticides were: diazinon, chlorpyrifos, α-endosulfan, β-endosulfan, dimethoate, omethoate, and heptachlor. Heptachlor was the most frequently detected contaminant (100%) and also had the highest violative level in markets (28.6%) while omethoate (41%) had the highest violative level vegetable farms. The lowest frequently detected pesticides are α-endosulfan (frequent in 11% of samples) in vegetable farms and chlorpyrifos (frequent in 12% of samples) in markets. The highest level detected corresponds to β-endosulfan (0.07 mg kg^{-1}) in markets while it corresponds to omethoate (2.44 mg kg^{-1}) in the farms. Fruits collected from South Khartoum (Jebel Aulia) contain the highest load (2.73 mg kg^{-1}) and most farmers interviewed in this location claim to overdose the crop. Sprays per season may reach an average between 5 - 7. Washing reduced the level of contamination especially; chlorpyrifos (85%), omethoate (100%) and dimethoate (100%). Regulatory monitoring programs for pesticide residues in food crops must be implemented and violative samples should be destroyed.

Keywords: *Pesticides Residue; Questioner; Knowledge; Snake Cucumber; Sudan*

Introduction

In Sudan vegetables are cultivated by small-scale farmers under either irrigated or rain-fed conditions in Gezira, Blue and White Niles in central Sudan, Kassala, River Nile, and Khartoum states. Vegetable production in Sudan has increased over the last twenty years. In 2017, vegetables were grown in more than 55609 ha [1]. Sudan is nominated as a major producer of vegetable crops for local consumption and could play significant role in alleviating the world food shortage, expected to occur in the near future [2]. Khartoum State is considered as the major site of production and consumption of vegetables in the country [3]. Guddoura [4] reported that vegetable and fruit production comprises more than 12% of the total agricultural output compared to 21% contributed by grains, 15% by cotton and 9% by

oilseeds in Sudan. The main vegetables grown are tomato, onion, eggplants, okra, potatoes, cucumbers, watermelon, carrot, sweet and hot peppers. Melons are believed to have originated in eastern Africa including Sudan. Four cultivated types of melons are grown in Sudan: sweet melon (cantaloupes), snake melon (cucumbers), the salad melon known locally as "Tibish" and Seinat (a melon with seeds eaten after roasting). Snake melon cultivars are local landraces named after the areas where they were developed. Snake cucumber (*Cucumis melo L*., var. *flexuosus*) belongs to the family Cucurbitaceous. It has high moisture content and rich in vitamins (A, C and B complex) and minerals (Ca, Fe, Mg, P, K and Zn), in addition to sugars and other carbohydrates. It is widely grown in Sudan and comprises about 9.4% (26441 ha) of the average area under vegetables [5]. Cucumbers are attacked by many pests and diseases. These pests and diseases are controlled by pesticides and fungicides. There are low levels of awareness among vegetable growers in general about safety aspects of pesticide use [6,7]. Normally farmers tend to overdose the pesticide and shorten the interval between sprayings. This may consequently lead to significant level of residues in the crop including the edible parts. Previous studies revealed the presence of some pesticides in various types of vegetables, fruits and soil and Nile water in the Sudan [6-17]. In some cases, violative levels were reported. Furthermore, there is no regular monitoring program of pesticides level in food items in Sudan and levels detected were based on sporadic studies done for personal interest or following specific accidents [19]. Based on the above points and considering the expected health and/or environmental effects of violative levels of pesticides residues especially in fresh vegetables such as cucumber this study was initiated to cast light on:

1. Residue levels of some of the commonly used pesticides on snake cucumber.
2. Evaluate the farmer's knowledge about safety aspects of pesticide use in Khartoum state.

Materials and Methods

Sample collection

Cucumber samples were randomly collected from four different locations: two main vegetables and fruits markets (Khartoum and Khartoum North markets), and two farms {from South Khartoum (Jebel Aulia) and west Omdurman areas}. Farmers in these sites were interviewed about pesticides used during the growing season, method of application, application rates, sprayers used and cultural practices through a short questionnaire.

Field survey and questionnaire

Field questionnaires were distributed to many farmers in the study area. The questionnaire included questions about the type of pesticides used, number of sprays per season, intervals between sprayings, pre-harvest intervals, recommended dose, personal safety and equipment decontamination methods, precautionary measure taken care of to prevent fruits contamination, health and environmental problems observed and knowledge of maximum residues level (MRL).

Chemicals and reagents

Anhydrous sodium sulfate, sodium chloride, acetone (99.8% pure), dichloromethane and n-hexane (99.98% pure) were purchased from Shifak Trade and Services CO. LTD, Khartoum Sudan. Analytical standards of pesticides (99% pure) including: diazinon, chlorpyrifos, imidacloprid, endosulfan, cypermethrin, cyfluthrin, deltamethrin, metalaxyl were obtained from Plant Protection Directorate Khartoum North, Sudan.

Sample preparation and extraction

Extraction of dislodgable residues

The cucumbers surfaces were washed with 10 ml of distilled water and the washings were collected in 50 ml Erlenmeyer flask. The collected washings were extracted three times with 50 ml dichloromethane and 10 ml saturated sodium chloride solution. The organic

phases were collected and passed through a layer of anhydrous sodium sulfate, then dried on a rotary evaporator and reconstituted in 10 ml n-hexane in a volumetric flask (10 ml) and kept at 4°C for GLC analysis.

Extractions of tissue residues

Each sample (1 kg) was chopped and mixed thoroughly. Fifty grams of the chopped samples were placed in a blender. A hundred milliliters of acetone, 5 ml water were added and blended at high speed for two minutes. The blended samples were filtered with filter paper Whatman No. 1. The filtrate was transferred to 250 ml separatory fennel and 50 ml of dichloromethane, 10 ml of saturated sodium chloride solution were added and the content was shaken vigorously by hand for one minute. The cock was opened several times to release the pressure. Then the separatory funnel was left standard for two minutes to allow separation of layers. The organic phase was collected in the Erlenmeyer flask, while the aqueous phase was re-extracted twice with 50, 30, 20 ml dichloromethane, respectively. The organic phases were recombined together and pass through a layer of anhydrous sodium sulphate. The solvent was removed to dryness by rotary evaporator under vacuum at 40ºC and the dried material was reconstituted in 10 ml *n*-hexane for clean-up.

Clean up

Clean up of extract was carried out by passing the extracts through a chromatographic column. Clean-up was done using a solid phase extraction (SPE) column containing Florisil® and anhydrous Na_2SO_4. The column was prewashed with 50 ml of acetone and *n*-hexane respectively. Finally, the extract was passed through the column and then eluted with a 125 ml mixture of acetone: *n*-hexane (3:7 v/v). The eluates were dried on a rotary evaporator under vacuum at 40^0C until complete dryness. The dried content was re-constituted in 10 ml *n*-hexane and kept in the refrigerator for GLC analysis.

Gas chromatographic analysis

The pesticide residue analysis was determined using a gas chromatograph (GLC) 2010 SHIMAZU, Kyoto system (Japan) with an AOC-5000 autosampler. The gas chromatography was equipped with RS5 capillary column 30m0.25 mm (i.d) with 0.25 mm film thicknesses from Restek (UK) and flame ionization detector (FID). Nitrogen (purity 99.999%) was used as a carrier gas at a flow rate of 1.69 ml/min. The splitless injection temperature was 230. The oven temperature was programmed from initial temperature of 50 held for one minute, then increased at 20 per minute at which it was held for 5 minutes, then increased to 230 at 3 per minute at which it was held for 5 minutes, and finally increased to 280 at 10 per minute, at which it was held for 2 minutes. The minimum detection level and retention time of standard pesticides were given in table 1. The recovery of the method ranged from 70 - 120%.

Pesticides	Minimum detection level $mgkg^{-1}$	Retention time (minutes)
Diazinon	0.77	18.992
Omethoate	3.11	23.391
Dimethoate	0.08	26.526
Heptachlor	0.05	30.764
Chlorpyrifos	0.03	32.682
Endosulfan alpha	0.003	36.808
Endosulfan beta	0.06	40.434

Table 1: *The minimum detectable level and retention time of standard pesticides.*

Results

Farmer's knowledge about precautionary measures and safety aspects

Result of questionnaire (Table 2) showed that 50% of farmers apply five sprayings per season, 25% apply six sprays per season and 25% apply seven sprays per season. The result also showed 50% of responding farmers used fifteen days interval, 25% used twelve days interval and 25% used ten days interval. Results also showed that 80% of farmers used recommended dose (all of South Khartoum (Jebel Aulia) and west Omdurman), 10% used high dose (Khartoum north market), and 10% sometimes used the recommended dose and sometimes used higher dose (Khartoum north market). Also results showed that all farmers washed and clean their bodies and their equipment after spraying, 50% of them put signs in the treated farms, and 25% did not use signs while 25% of them sometimes use signs. As for health problems, 50% of farmers observed sensitivity of nose, eyes, chest and abdominal cramp, while 50% of them don't observe any health problems. The environmental problems claimed by the respondents are: 25% of farmers observed death of some birds and fishes while 75% did not observe any negative impacts. Only 25% of interviewed farmers claimed that they were aware of the maximum residue levels (MRLs) while the majority of them (75%) were ignorant about this important quality parameter.

Locations	South Khartoum (Jebel Aulia)	West Omdurman	Khartoum Market	Khartoum North Market
Number of sprayings/season	5	6	5	7
Interval between sprayings (days)	15	12	10	15
Recommended dosage followed %	10	90	90	10
Personal safety and equipment decontamination %	75	80	60	65
Problems of contaminated vegetables %	85	30	65	20
Health problem observed %	80	75	70	40
Environmental problems observed%	75	90	65	90
Knowledge of (MRLs) %	45	65	50	10

Table 2: *Farmer response about safety, health and environmental problems observed. (MRLs): Maximum Residual Levels.*

Pesticides residues detected in samples collected from vegetable markets in Khartoum state

The result of the market samples (Table 3) showed the presence of pesticide residue in 63.5% of the samples. Residues of the following pesticides were detected in the washings (dislodgable); dimethoate, heptachlor, α-endosulfan, omethoate, diazinon, and chlorpyrifos while the followings pesticides were detected inside cucumber tissue; heptachlor, β-endosulfan, dimethoate, and diazinon. Heptachlor was the most frequently detected contaminant in the washings (100%) followed by omethoate (85%) and dimethoate (55.5%). Heptachlor was also the most frequently contaminant detected inside cucumber tissue (100%), followed by β-endosulfan (34.3%) and diazinon (26.8%). The highest average level detected in whole fruits corresponds to β-endosulfan 0.07 ppm followed by dimethoate 0.06 ppm and heptachlor 0.05 ppm, while the lowest level detected corresponds to omethoate 0.02 ppm. The highest percentage of violative samples corresponds to heptachlor (28.6%) while the lowest violative corresponds to chlorpyrifos (12%).

Pesticides	Khartoum North				Khartoum			MRLs (EU 2016)
	Parameter	Washing	Inside tissues	Whole fruits	Washing	Insides tissues	Whole fruits	
Dimethoate	Average	0.06	ND	0.06	ND	ND	ND	0.01
	Range	0.035-0.088	ND	ND-0.088	ND	ND	ND	
	Median	0.063	ND	0.063	ND	ND	ND	
	Samples tested	ND	ND	ND	ND	ND	ND	
	+ve (%)	55.6	ND	55.5	ND	ND	ND	
	Violative samples (%)	15.97		15.97				
Diazinon	Average	ND	0.04	0.04	0.04	ND	0.04	0.01
	Range	ND	0.026-0.053	ND-0.053	0.021-0.065	ND	ND-0.065	
	Median	ND	0.051	0.051	0.049	ND	0.049	
	Samples tested	ND	26.8	26.8	30.77	ND	30.77	
	+ve (%)	ND	25	25	22	ND	22	
	Violative samples (%)							
Chlorpyrifos	Average	0.03	ND	0.03	ND	ND	ND	0.01
	Range	0.039-0.071	ND	ND-0.071	ND	ND	ND	
	Median	0.051	ND	0.051	ND	ND	ND	
	Samples tested	ND	ND	ND	ND	ND	ND	
	+ve (%)	38.7	ND	38.7	ND	ND	ND	
	Violative samples (%)	12		12				
Omethoate	Average	ND	ND	ND	0.02	ND	0.02	0.01
	Range	ND	ND	ND	0.021-0.044	ND	ND-0.044	
	Median	ND	ND	ND	0.022	ND	0.022	
	Samples tested	ND	ND	ND	85	ND	85	
	+ve (%)	ND	ND	ND	25.8	ND	25.8	
	Violative samples (%)							
Total Ops		0.09	0.04	0.13	0.06	ND	0.06	

Heptachlor	Average	0.05	0.04	0.09	0.03	0.03	0.06	0.01
	Range	0.028-0.079	0.026-0.052	0.02-0.08	0.02-0.07	0.020-0.052	0.02-0.07	
	Median	0.058	0.049	0.11	0.039	0.032	0.071	
	Samples tested +ve (%)	100	100	100	100	100	100	
	Violative samples (%)	17.94	15	32.97	26.8	28.6	55.2	
Endosulfan alpha	Average	ND	ND	ND	ND	ND	ND	0.05
	Range	ND	ND	ND	ND	ND	ND	
	Median	ND	ND	ND	ND	ND	ND	
	Samples tested +ve (%)	ND	ND	ND	ND	ND	ND	
	Violative samples (%)	ND	ND	ND	ND	ND	ND	
Endosulfan beta	Average	ND	ND	ND	ND	0.07	0.07	0.05
	Range	ND	ND	ND	ND	0.056-0.093	ND-0.093	
	Median	ND	ND	ND	ND	0.074	0.074	
	Samples tested +ve (%)	ND	ND	ND	ND	34.31	43.31	
	Violative samples (%)	ND	ND	ND	ND	13	13	
Total OCs		0.05	0.04	0.09	0.03	0.1	0.13	
Total		0.14	0.8	0.22	0.9	0.1	0.19	

Table 3: *Levels of pesticides residues mg kg^{-1} detected in samples collected from markets (Khartoum and Khartoum North) of Khartoum State.*

*ND: Not detected. *Percentage of samples with level exceeding the MRLs, cited by European Commission.*

Pesticides residues detected in samples collected from vegetable farms at Khartoum State

The result of the farms sample (Table 4) showed the presence of pesticide residues in 36.5% of the samples. Residues of the following pesticides were detected in the washings (dislodgable); omethoate, dimethoate, heptachlor, β-endosulfan, and diazinon while the following pesticides were detected inside cucumber tissue; dimethoate, heptachlor, chlorpyrifos, and α-endosulfan. Heptachlor was the most frequently detected contaminant in the washings (100%) followed by omethoate (88.8%) and β-endosulfan (76%), while heptachlor was most frequent contaminant detected inside cucumber tissue also (100%), followed by α-endosulfan (61%) and dimethoate (34%). The

highest level detected in the whole fruit corresponds to omethoate 2.44 ppm, followed by chlorpyrifos 0.14 ppm and heptachlor 0.12 ppm while the lowest level detected corresponds to α-endosulfan 0.002 ppm. The highest percentage of violative samples corresponds to omethoate (41%) while the lowest violative corresponds to β-endosulfan (11%).

Pesticides	South Khartoum (Jebel Aulia)				West Omdurman areas			MRLs (EU 2016)
	Parameter	Washing	Inside tissues	Whole fruits	Washing	Insides tissues	Whole fruits	
Omethoate	Average	2.44	ND	2.44	ND	ND	ND	0.01
	Range	1.88-3.11	ND	ND-3.11	ND	ND	ND	
	Median	2.33	ND	2.33	ND	ND	ND	
	Samples tested +ve (%)	88.8	ND	88.8	ND	ND	ND	
	Violative samples (%)	41	ND	41	ND	ND	ND	
Chlorpyrifos	Average	0.12	0.02	0.14	0.07	ND	0.07	0.01
	Range	0.09-0.14	0.01-0.03	0.01-0.14	0.04-0.09	ND	ND-0.09	
	Median	0.11	0.02	0.13	0.08	ND	0.08	
	Samples tested +ve (%)	39	20	59	28.08	ND	28.08	
	Violative samples (%)	12.6	ND	12.6	13	ND	13	
Diazinon	Average	ND	ND	ND	ND	ND	ND	0.01
	Range	ND	ND	ND	ND	ND	ND	
	Median	ND	ND	ND	ND	ND	ND	
	Samples tested +ve (%)	ND	ND	ND	ND	ND	ND	
	Violative samples (%)	ND	ND	ND	ND	ND	ND	
Dimethoate	Average	ND	0.05	0.05	ND	ND	ND	0.01
	Range	ND	0.03-0.07	ND-0.07	ND	ND	ND	
	Median	ND	0.05	0.05	ND	ND	ND	
	Samples tested +ve (%)	ND	34	34	ND	ND	ND	
	Violative samples (%)	ND	25	25	ND	ND	ND	

Total Ops		2.56	0.07	2.63	0.07	ND	0.07	
Heptachlor	Average	0.07	0.03	0.1	0.06	0.06	0.12	0.01
	Range	0.05-0.09	0.02-0.05	0.02-0.09	0.04-0.09	0.03-0.08	0.03-0.09	
	Median	0.07	0.04	0.11	0.07	0.06	0.13	
	Samples tested +ve (%)	100	100	100	100	100	100	
	Violative samples (%)	24.2	25	49.2	24	15	39	
Endosulfan alpha	Average	0.002	ND	0.002	ND	0.05	0.05	0.05
	Range	0.001-0.003	ND	ND-0.003	ND	0.03-0.09	ND-0.09	
	Median	0.002	ND	0.002	ND	0.05	0.05	
	Samples tested +ve (%)	76	ND	76	ND	61	21.6	
	Violative samples (%)	ND	ND	ND	ND	11	11	
Total OCs		0.072	0.03	0.102	0.06	0.11	0.17	
Total		2.632	0.1	2.732	0.13	0.11	0.24	

Table 4: *Levels of pesticides residues mg kg^{-1} detected in samples collected from (South Khartoum (Jebel Aulia) and west Omdurman areas) farms of Khartoum State*
*ND: Not detected. *Percentage of samples with level exceeding the MRLs, cited by European Commission, 2016.*

Discussion

Field survey

The field survey revealed that cucumber production in the studied locations was dominated by old farmers with the mean age of 42 years. The majority (60%) fall within the age range of 32 - 54 years, with average farming experience of 23 years and a range of 13 - 37 years. The old ages of farmers coupled with cumulative long farming experience may positively affect their perception of pesticides. This agrees with Bonabana [20] who reported that old farmers are likely to perceive the environmental hazards of pesticides than the young farmers due to accumulated knowledge and experience of farming systems. It also agrees with Ntow., *et al*. [21] who reported that various inappropriate practices in the handling and use of pesticides caused possible poisoning symptoms among those farmers who generally did not wear protective clothing. Younger farmers (< 40 years of age) were the most vulnerable group, probably because they carry out more spraying operations by themselves than older farmers (> 40 years of age). The survey also shows that 30% of respondents are illiterates and 60% of them had primary or basic education while the remaining 10% attended secondary schools. The low education levels among farmers may negatively affect their ability, especially illiterates and primary school attendants, to read and understand the instructions on pesticide containers which may intern reduce and/or prevent pesticide misuse [6]. The survey also shows that 10% of the respondents had training through their contact with the extension agents while 90% of them claimed to have no contact with an extension agent. The lack of training may contribute to the misuse of pesticides. This agrees with the report by Alam [22] and Cornwall., *et al*. [23] who mentioned that the illiteracy rate among farmers and agricultural workers is quite high in many third world countries, therefore,

farmers cannot read pesticide instruction labels. They further added that farmers lack training on the application methods of safe use of pesticides, do not wear any protective clothing, and are ignorant about safe storage and appropriate disposal of residuals. The current results show that only 20% of farmers read pesticide labels before use whiles the others (80%) did not and the majority of farmers (80%) did not use the recommended dose or respect prohibition period. This agrees with the report of Dossari., *et al*. [24] and Taj al-Din., *et al.* [25] who mentioned that most farmers do not follow the instructions available on the packaging labels and do not follow proper application methods and precautionary measures. Relatively few numbers of the respondents read the labels to know the pesticide and its anti-poison cautions. Pesticides packaging must contain all the information on the use, application method, toxicity level, recommended dose, safety period and all other necessary precautionary measures to be taken before, during and after the use. Hong and Yonglong [26] mentioned that a high level of knowledge about pesticide hazards at the end-users of pesticides is important for the prevention of acute poisoning. Availing training to farmers will improve their perception of pesticides and improve their attitude towards adoption of safe use. The current results call for immediate extension intervention to be available to farmers in the studied areas to improve their skills and attitude towards adoption of safe use of pesticides as had been the case two decades ago during the FAO funded IPM projects on cotton and vegetables. This extension services available to farmers during the above-mentioned projects showed that participants of FFS adopted the use of soft chemicals (pyrethroids) in controlling insect pests in their tomato fields in Gezira Scheme and Khartoum state. FFS participants became more aware towards the reduction of insecticide applications. The survey also confirms that all farmers (100%) had use chemicals in their farms [27, 28]. The current results showed that all farmers (100%) had use chemicals in their farms. Pesticides claimed to be commonly used by the farmers include: diazinon (90%), carbaryl (as Sevin) (70%), malathion (60%), cypermethrin (50%), and carbsulfan (as Marshal) (50%). This is an indication that pesticides play an important role in the control of pests in these locations. The current results show that a number of spraying per season ranged from 5 to 7 with intervals of 7-20 days. Framers rely on their own or colleagues experiences when deciding the number and intervals of sprayings. Similar findings were reported by Dabrawski [29] who mentioned that farmers in central Sudan spray tomato every 3 - 7 days from first week of seed germination to harvest. The results also revealed that farmers overdosed the pesticides regardless of effectiveness and side effects and 80% of farmers observed environmental problems in their fields and the surroundings. The negative effects on the environment may be explained by their weak knowledge about maximum residual levels (MRLs) and other safety measures. Ellis [30] mentioned that MRLs represent a primarily check that good agricultural practice is being followed and can reduce product rejection in international trade Edwards [31] reported that pesticides could become a nuisance if they are misused. Some of the negative effects of pesticide misuse include low crop yield, destruction of soil microfauna and flora, and undesirable residue accumulation in food crops. Further Kriengkrai [32], mentioned that the overuse and misuse of pesticides are detrimental to the health of users, consumers and the environment.

Pesticides analysis

The results of residue analysis revealed the presence of seven pesticides. Heptachlor is detected in all samples from all locations. This pesticide was a known POPs chemical who was never registered for use in vegetables in Sudan and even its use in cotton and sugar cane was severely restricted in 1994 (for the purpose of termite control only) and completely banned by 2002 [33]. Therefore, the source of its residues in the samples might be from previous soil contamination. Abdelbagi., *et al*. [11], El mahi., *et al.* [34] and Abdelbagi., *et al*. [10,11], mentioned this pesticide was the most frequently detected contaminant in soil and blood samples from areas of both intensive and limited pesticides use in the Sudan. According to the FAO [5] obsolete unwanted and banned pesticides, PTS and POPs pose serious environmental hazards, especially where they are stocked and mostly neglected. Babiker [35] investigated pesticide residues in four drinking wells near Qureshi pesticide store 11 years after the pesticide dumping incident. He found measurable levels of heptachlor in three wells at a range of 0.003 - 0.065 ppm. EPA [36] mentioned that Heptachlor Have been banned, because of their toxicological effects on humans, animals, crops and the environment. The result also showed that heptachlor is the most frequently detected contaminant inside tissues as well as in the washings of all samples from all locations (100%). The result also revealed that omethoate had the highest detected level in whole fruit (2.44 ppm); this could indicate that this pesticide has been used recently in this location or might have been repeated sprayed or used at high concentration. This agrees with the results of Mohammed., *et al*. [37] from Yemen who mentioned that

dimethoate and omethoate residues were the highest in the soil samples collected from the upstream locations of the Zedan valley, Yemen (5.180 and 0.020 mg/kg dry weight soil, respectively). The result also shows that α-endosulfan had the lowest detected level in the washing water and inside fruits tissues of all samples from all locations (0.002 ppm). The sources of detected pesticides may be the past use of these pesticides or transport from other farms around the field. This agrees with Nannyonga., *et al*. [38] who reported that fresh cucumbers from Kampala and Mukono markets contain very low amounts of organochlorine pesticides within the recommended limits set by European Union Commission, Levels of α-endosulfan residue in cucumbers were 0.032 and 0.037 ppm. The result showed that the amount of pesticides detected on the washings (4.16 ppm) were high than those detected inside the tissue fruits (1.11 ppm). Washing was found to reduce the residue levels of pesticides in the current study especially chlorpyrifos, omethoate, and dimethoate. The fruits rinds receive chemicals before penetrating and entering in the fruits and the washing remove pesticides from fruits or minimize them. Elbashir., *et al.* [9] found residues of pesticides generally higher than MRLs but single or several washings significantly remove the residues to levels lower the recommended MRL in most cases. Robertson [39] reported that washing is an important process which can cause significant reduction in pesticides residues, especially in smooth surface fruits. The result shows that, South Khartoum (Jebel Aulia) fruits had the highest contamination (0.002 - 2.44 ppm.) compared to other locations. This might indicate that farmers from this location had limited information about safety measures during pesticides application and may tend to misuse the pesticides. This might call for immediate extension intervention to those farmers. Fruits collected from markets showed the highest violation which associated mainly with heptachlor (28.6%) while the lowest percentage of violations corresponds to chlorpyrifos (12%). On the other hand omethoate caused the highest violations (41%) in fruits collected from farms while the lowest violation in farm fruits were found associated with endosulfan beta (11%). This result generally agreed with Elbashir., *et al*. [9] who found comparable results in open field tomato samples.

Conclusion

Measurable residue levels of some pesticides were detected in snake cucumber (*Cucumis melo* L., var. *flexuosus*) fruits samples collected from farms and markets in Khartoum State. Detected pesticides includes; heptachlor, chlorpyrifos, α-endosulfan, β-endosulfan, dimethoate, omethoate and diazinon. Heptachlor was the most frequently detected contaminant (detected in all samples) while the lowest frequently of detection was associated with α-endosulfan (11%) in vegetable farms and chlorpyrifos (12%) in markets. The highest detected level corresponds to endosulfan beta (0.07 ppm) in market samples and omethoate (2.44 ppm) in the farm samples. The highest violative level in markets fruits were caused by heptachlor (28.6%), while omethoate had the highest violative levels in vegetable farms (41%). The highest load (mg/kg fruit) was detected in South Khartoum (Jebel Aulia) market samples (2.73 ppm) while the lowest load was detected in Khartoum North market samples (0.19 ppm). Fruits collected from South Khartoum (Jebel Aulia) farms contain the highest load and most interviewed farmers in this location claim to over dose the pesticides with 5 - 7 sprays per season. Similarly misuse and low extension services were indicated by the responding farmers especially in Khartoum North market. Washing reduce the level of contamination particularly those of chlorpyrifos, omethoate, and dimethoate.

Conflict of Interest

The authors declare no conflict of interest.

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