



## Investigation on Organochlorine Pesticides Residues and Trace Metals in Melon (*Colocynthis citrullus* L.): A Survey

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### ABSTRACT

Several nations of the world are facing crisis level of acute food security and malnutrition which required urgent attention. Melon very rich in protein, oil, minerals, vitamins and good source of energy. As a result, the high contamination of melon with heavy metals and pesticide residues threatens human and ecosystem. Organochlorine Pesticides (OCPs) and trace metals were undertaken in melon obtained from five major towns in Nigeria. Analytical instruments were used to analyze the extracted OCPs from dichloromethane and digested melon samples, respectively. The overall metal content per site of the studied elements in the selected sites was determined and it was in the following decreasing order: Mokwa > Bida > Suleja > Borgu > Saki. The mean metal concentrations were in the following decreasing order: Pb > Zn > Ni > Co > Cd. With exceptions of locations where Ni and Pb were below detection limit, the concentrations of Pb, Cd and Ni in other locations were above WHO/FAO recommended limit. Concentrations of Zn and Co were below WHO/FAO limits. Out of 17 isomers of OCPs analyzed only five isomers were detected. The overall OCPs content per site of the studied elements in the selected sites was determined and it was in the decreasing order: Bida > Borgu > Saki > Suleja. OCP was not detected in melon samples obtained from Mokwa. With exception of endosulfan II, endrin aldehyde, heptachlor, DDE and  $\lambda$ -BHC were above their respective maximum residual limit. Environmental monitoring and education are highly recommended.

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## INTRODUCTION

Many countries of the world are facing crisis level of acute food security and malnutrition which required serious attention. Statistically, in 2017, 124 million people in 51 countries and in 2016, 108 million in 48 countries across the globe faced crisis levels of acute food security. Eleven of these countries are from Africa accounting for 37 million in which the largest number were in North-Eastern Nigeria, Republic of Congo, Somalia and Southern Sudan [1]. According to GRFS [1], malnutrition is defined as anomalous physiological disorder caused by deficiencies, excesses or imbalance in energy and or nutrients for an active, health life. This include under nutrition, micronutrients deficiencies, overweight and obesity. Malnutrition of all forms may be attributed to inadequate nutrient intake, repeated infectious diseases and or poor care and feeding practices.

Melon (*Colocynthis citrullus* L.), a herbaceous annual vegetable belonging to the family *Cucurbitaceae* is an important globally. Melon is usually planted during the rainy

season and maturity stage is usually three to four months. The crop is usually inter-planted with some other tuber crops such as yam, cassava [2, 3] act as a source of weed [4] and runoff as well as soil enrichment. In Nigeria, the seed are usually consumed as a thickening for soup and sauce; sometimes fried and eaten as snack [5]. A valuable oil may be extracted from the seed which can be used in cooking and fry cake.

The oil and the seed are very rich in protein, oil, minerals, vitamins and good source of energy [2, 3]. Olaniyi [6] reported that the seed contain carbohydrate (4.6 g), protein (0.6 g), crude fibre (0.6 g), vitamin C (33 mg), calcium, Ca (17 g), phosphorus, P (16 mg), and potassium, K (230 mg) per 100 g edible seed. According to Albishri et al. [7] the seed oil contains 31.0 – 69.0 % linoleic acid, 12.1 -31.0 % oleic, 7.8 - 39.36 % palmitic and 4.9 -10.45% stearic acid. It was stated by Ivanova [8] that melon contain glucose, fructose and sucrose (4.6 to 16.0 or 18.0 %), starch (4.5%), pectin, vitamin A, C, D, K from group B and E, carotene, folic, K, magnesium (Mg), P, sodium (Na), selenium (Se) and Ca and many aromatic compounds.

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According to Jeffrey [9] melon has admirable taste and medicinal value. Chen et al. [10] and Gill et al. [11] reported that it is recommended in treatment of liver, kidney and cardiovascular diseases, other ailments are: gout, rheumatism and patient with atherosclerosis in situation of anemia. Melon has good phyto-chemical properties such as anti-inflammatory, analgesic and anti-oxidant properties [10, 11]. Azhari et al. [12] stated that melon seed oil is very rich in sterols, phospholipids and tocopherols.

Despite the fact that metals occur naturally in the soil, it is the anthropogenic activities that increase their amount in the soil and other environmental factors which portends human and ecosystem health. Anthropogenic activities such as mining, sewage sludge, waste water disposal, urban effluent, vehicle exhausts and agrochemicals can greatly affect heavy metal concentrations in soil [13]. Heavy metals in soil tend to interrupt soil function, bioaccumulate in plant and translocate into various organs of the crop.

Soil contamination by heavy metals may pose risks and health hazards to humans and the ecosystem in various ways such as direct assimilation, exchange with contaminated soil, consumption of contaminated water, the food chain, drop in food quality through phytotoxicity, decline in land usability for agricultural practices thereby given rise to food uncertainty, and land tenure problem [14].

Many prominent pesticides used extensively in agriculture possess substantial levels of metals, for instance, Bordeaux a mixture of copper sulphate and copper oxychloride chemicals is capable of aggregate the levels of copper in the soil [15]. Furthermore, application of animal manure, compost and household sewage may also contribute to the contamination of soil with heavy metals [16]. Copper and zinc growth promotant additives in poultry feed and arsenic in poultry health product are potential heavy metal contaminant in soil [17, 18].

Chlorinated organic pesticides reevaluated to be highly noxious, harmful and persistent in the environment [19]. It can accumulate in human as well as in animal bodies because it has ability to solubilize in fats and causes health problems such as cancer and hematopoietic, nephrotoxic, hepatotoxic, and reproductive diseases. Moreover, they also affect hormonal system, and may have interactive effects by producing both androgenic and estrogenic responses in vertebrates. In invertebrates this pesticides may cause endocrine disruption, neurological and immunodeficiency disorders [20]. DDT like other OCs is not acutely toxic which the major reason of its widespread use. It persists for a long time in environment, and accumulates in food and animal tissues. The inadequate use of DDT resulted in worldwide pollution which makes it a threat for whole web of life. The residues of DDT mainly its metabolite DDE was observed in all fish eating birds, in fishes it is the major cause of reproductive failure [21]. DDT persists for very long time and stored in various tissues with highest accumulation in fat where repeated exposure accumulates high concentration. This property of storage in all tissues causes serious health issues mostly in occupational exposure to DDT. Various reports have confirmed its carcinogenic effects as it is the major cause of pancreatic cancer, liver cancer and multiple myeloma [22]. Endosulfan is one of the OCs that has found to use very extensively. The enormous use of endosulfan makes

it vulnerable for the whole environment. The extensive use of endosulfan deteriorate soil quality, its biology, fertility, health and productivity [23]. The most alarming chronic symptoms, like testicular and prostate cancer, breast cancer, sexual abnormality, endocrine disruption and stomach contact poison, has also been reported by endosulfan. Lindane is used as an insecticide on fruits and vegetables. It is an organochlorinated insecticide has severe health effects. In humans it also causes induce membrane perturbation, functional impairment in blood brain barrier, disturbance in glutathione homeostasis and alteration in monooxygenase enzymes [24] which ultimately causes neurotoxicity.

The occurrence of pesticides in our environment as a result of the indiscriminate or intentional use has resulted in its persistence in the environment, thereby affecting the ecosystems and non-target organisms. Acute and chronic pesticide poisoning usually results from consumption of contaminated food, chemical accident in industries and occupational exposure in agriculture. Hence, this study aimed to assess the levels of trace metals and organochlorine pesticides residue in melon seeds.

## MATERIALS AND METHODS

### Sampling

The study was performed in five different towns namely, Borgu, Suleja, Mokwa, Bida and Saki from five different Local Government in Nigeria, four of which from northern state and one from south-west Nigeria. Two kilograms of melon were purchased from each town.

### Trace metals analysis

The melon seed (1.0 g) were digested for trace metals analysis by adding 5 mL of nitric followed by adding 1 mL of perchloric acid after heating for about 10 min. The heating was continued gently until frothing subsided. The sample was heated until near dryness, allowed to cool and filtered into 25 ml standard flask. The filtrate was then made up to the mark with distilled water.

From stock solution, the calibration curves for heavy metals were plotted at several levels (0.25, 0.5, 0.75, 1.0, 2.0, 0.35, and 5.0 mg/L). Stock solution was prepared from standard reference materials (1000 ppm). The linearity of the calibration plots attained were: Co (0.99956), Zn (0.99940), Pb (0.99798), Cd (0.99987), and Ni (0.99617), respectively. The limit of detection (LOD) and Limit of quantification (LOQ) for the trace metals were Ni (0.008: 0.08); Cd (0.0028: 0.028), Pb (0.012:0.12), Zn (0.003:0.03), and Co (0.02:0.2).

### Extraction, cleanup and gas chromatography analysis

Soxhlet extractor was employed in extracting 20 g each of the sample using dichloromethane as solvent. Extraction was performed for 4 h until clear solvent was observed. The cleanup of the samples was performed by silica gel (60-120 mesh) chromatography and the final elution was achieved by using dichloromethane. The eluate was concentrated under vacuum to about 1 mL and store in a well labelled vials prior GC analysis.

Qualitative and quantitative analysis of organochlorine was carried out by Agilent 7890A gas chromatography with a splitless injector port equipped with electron capture detector

and a DB 17 30 m (length)  $\times$  250  $\mu$ m  $\times$  0.25  $\mu$ m film thickness column. The injector temperature was 250°C. There was split flow rate of 2 mL/min during an oven temperature of 150°C which was increased to 280°C at 6°C/min, the total run time was 21.67min.

The chromatograms of the chlorinated organic compounds mix standards (2 ng/ $\mu$ L) and representative chromatograms of chlorinated organic compounds of melon sample analyzed are shown in Figure 1. The peak areas of the several peaks whose retention times correspond with the standards were inferred on their equivalent calibration curves to attain the

concentration. The retention times for heptachlor,  $\lambda$ -BHC, p,p' - DDE, endosulfan II and endrin aldehyde are: 8.229, 9.958, 13.770, 16.503 and 17.681 minutes, respectively. The limits of detection and quantifications (ng/ $\mu$ L) were: heptachlor ((0.094; 0.94),  $\alpha$ BHC (0.065; 0.65),  $\beta$ BHC (0.094; 0.94);  $\lambda$ -BHC (0.057; 0.57),  $\delta$ BHC (0.017; 0.17), p, p' -DDT (0.078; 0.78), p, p' -DDE (0.040; 0.40), p, p' -DDD (0.082; 0.82), aldrin (0.031; 0.31), heptachlor epoxide (0.023; 0.23), dieldrin (0.071; 0.71), endrin (0.112; 1.12) endosulfan II (0.141; 1.41), and endrin aldehyde (0.057; 0.57), endosulfan sulphate (0.122; 1.12) and methoxychlor (0.405; 4.05), respectively.

## RESULTS AND DISCUSSION

### Heavy metals

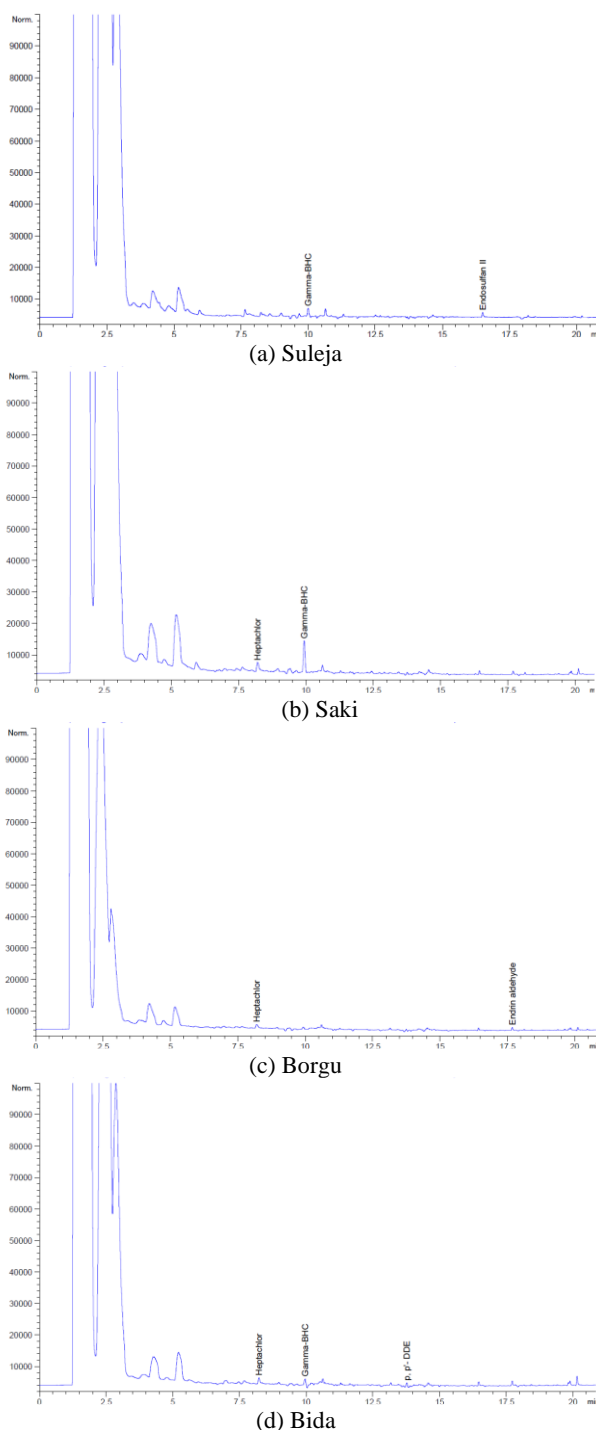
Five metals cadmium, Zn, Co, Pb, and Ni were analyzed from melon seeds obtained from the five towns in five different local governments of Nigeria and the obtained results are presented in Table 1.

The total metal burden per site of the studied elements in the selected sites was determined and it was in the following decreasing order: Mokwa > Bida > Suleja > Borgu > Saki. The overall metal concentrations were in the following decreasing order: Pb > Zn > Ni > Co > Cd. Cadmium is not known for any essential biological function. The concentrations of Cd were found to be in the range of 0.1 mg/kg to 1.35 mg/kg which were well above the WHO/FAO limits of 0.05. This is very dangerous as cadmium poisoning can lead to painful bone disease combined with kidney malfunction [25].

Zinc is an essential trace element for both animals and humans. A deficiency of Zn is marked by retarded growth, loss of taste, and decreased fertility. High concentrations of Zn can cause irritability, muscular stiffness and pain, loss of appetite, and nausea [26]. Borgu local government had the highest concentration of zinc at (16.85 mg/kg) and Mokwa local government area had the lowest at (5.23 mg/kg) which is lower than the WHO/FAO limit of 50 mg/kg.

Lead accumulates in the body organs (i.e., brain), which may lead to poisoning or even death. The gastrointestinal tract, kidneys, and central nervous system are also affected by the presence of lead. Children exposed to lead are at risk for impaired development, lower IQ, shortened attention span, hyperactivity, and mental deterioration, with children under the age of six being at a more substantial risk. Adults usually experience decreased reaction time, loss of memory, nausea, insomnia, anorexia, and weakness of the joints when exposed to lead [27]. Lead performs no known essential function in the human body, it can merely do harm after uptake from food, air, or water. Only three of the five local government contained Pb and their concentrations were at very alarming rates. Mokwa had the highest concentration at (19.75 mg/kg), Bida at (13.70 mg/kg) and Suleja at (11.43 mg/kg) which are all way above the WHO/FAO limits at 0.05 respectively. The gastrointestinal tract, kidneys, and central nervous system can be affected by high concentrations of Pb.

Nickel is an element that occurs in the environment only at very low levels and is essential in small doses, but it can be dangerous when the maximum tolerable amounts are exceeded. This can cause various kinds of cancer on different



**Figure 1.** (a-d) Chromatograms of OCPs residues in melon seed of the sites considered in this study

**TABLE 1.** Concentration of Trace Metals (mg/kg) in melon seeds

Location	Cd	Zn	Co	Pb	Ni	Total Metal Burden
Bida	0.10±0.000	8.33±0.050	< 0.02	13.7±0.050	1.78±0.025	23.9
Borgu	0.53±0.050	16.9±0.050	0.475±0.025	< 0.012	1.63±0.050	19.5
Mokwa	1.35±0.500	5.3±0.050	2.300±0.050	19.8±0.250	3.56±0.050	32.2
Saki	1.00±0.000	9.23±0.025	< 0.02	< 0.012	< 0.008	10.2
Suleja	0.43±0.025	6.18±0.025	2.58±0.025	11.4±0.050	< 0.008	20.6
WHO/FAO	0.05	50	50	0.05	0.5	

sites within the bodies of animals. Mokwa had the highest concentration at (3.55 mg/ kg) followed by Bida at (1.78 mg/ kg) while that of Borgu was (1.63 mg/ kg). All these concentrations exceeded the WHO/FAO limits of 0.5 mg/kg.

Cobalt is essential in trace amounts for humans and other mammals as it is an integral component of the vitamin B12 complex but in higher it causes respiratory irritation, wheezing, asthma, decreased lung function, pneumonia, and fibrosis. Co was not in detected in Bida and Suleja. Suleja had a concentration of 2.58 mg/ kg while Borgu and Mokwa had 0.48 mg/ kg and 2.30 mg/kg respectively. Cobalt in the in these samples were all within the WHO/FAO limit of 50 mg/kg.

Oluwabamiwo [28] carried out research on heavy metals analysis of melons seeds from Lagos state, Nigeria. The research revealed the concentrations of Pb, Cd, Zn to be 0.05 mg/kg, 0.005 mg/kg and 8.18 mg/kg, respectively. Lead concentration was below the WHOFAO limit, Cd was also lower than the WHO/FAO limit, and Zn was within the WHO/FAO limit.

Lanre-Iyanda and Adekunle [29] investigated the presence of some heavy metals in melon cakes (called Robo in Yoruba) sold at different motor parks in Abeokuta, Nigeria, the motor parks were Asero, Adata, Sapon, Ia-oshin, Lafenwa, Itoku, Kuto. The concentrations were Zn (ranged from 16.15 to 21.78 mg/kg) all the concentrations of zinc were within the FAO/WHO limit, Cd (ranged from 0.028 to 0.057 mg/kg) the concentrations of cadmium in Lafenwa motor park was slightly above the WHO/FAO limit, Pb (ranged from 13.83 to 19.88 mg/kg) Pb in the melon cakes from the different motor parks were all above the WHO/FAO limit of 0.05 mg/kg, Ni (ranged from 0.04 to 0.15 mg/kg) Ni in all the melon cakes from the different motors parks were below the

limit. In comparison of the values reported by Lanre-Iyanda and Adekunle [29] to the values obtained in this study, the Zn concentrations in this study were lower. The Cd and Ni values in this study were higher, while the Pb values were in close ranged.

Ogunkunle et al. [30] carried out research on the analysis of heavy metals in some fruits and vegetables from Lagos. One of the fruits on which heavy metals analysis was carried out is watermelon, the concentrations of Co, Zn, Pb, Ni, Cd were found to be 0.02 mg/kg, 0.05 mg/kg, 1.76 mg/kg, 0.14 mg/kg, and 0.004 mg/kg, respectively. Only that of Pb was higher than the WHO/FAO permissible limit.

Savsatli et al. [31] reported on presence of some heavy metals in bitter melon seeds grown in Pazar district of Rize Province in Black Sea Region of Turkey. The concentrations (mg/0.1 kg) were Cd (0.002), Pb (0.02), Zn (0.04), Ni (0.03) these values are lower than the values obtained in this study. Verma [32] also carried out a similar research in bitter melon seeds Zn (49.09 mg/kg), Co (3.86 mg/kg) the Zn and Co concentrations are higher than the concentrations of Zn and Co in this study. These values are within the FAO/WHO permissible limit.

### Chlorinated organic compounds

Generally, out of seventeen isomers of chlorinated organic compounds analyzed only five isomers were detected in all, two isomers of cyclodienes, one isomer each form dichloro diphenylethenes and hexachlorocyclohexane.

Table 2 presents mean levels of cyclodienes compounds in melon seed. In Nigeria, heptachlor was among the ban chemicals. Heptachlor concentration (mg/kg) is observed in Bida, Borgu and Saki. Saki had the highest concentration (0.067 mg/kg) followed by Bida (0.037 mg/kg) and the lowest

**TABLE 2.** Mean concentrations (mg/kg) of cyclodienes in Melon Seed

OCPs	Bida	Borgu	Mokwa	Saki	Suleja	MRL
Heptachlor	0.037±0.00	0.026±0.00	< 0.0094	0.067±0.00	< 0.0094	0.02
Hept-epoxide	< 0.023	< 0.023	< 0.023	< 0.023	< 0.023	0.02
Aldrin	< 0.031	< 0.031	< 0.031	< 0.031	< 0.031	0.05
Dieldrin	< 0.072	< 0.072	< 0.072	< 0.072	< 0.072	0.02
Endrin	< 0.112	< 0.112	< 0.112	< 0.112	< 0.112	0.01
Endrin CHO	< 0.057	0.07±0.00	< 0.057	< 0.057	< 0.057	0.01
Endosulfan I	< 0.060	< 0.060	< 0.060	< 0.060	< 0.060	0.10
Endosulfan II	< 0.141	< 0.141	< 0.141	< 0.141	0.062±0.00	0.10

Borgu at 0.026 mg/kg. Heptachlor concentrations observed in this study were above the MRL value. The principal contact of human beings to heptachlor is via contaminated foods [33]. The farmers engaged in the use of heptachlor to kill ants, termites and other soil insects and on crops [34]. Endosulfan has two isomers ( $\alpha$ ,  $\beta$ ) and their metabolite is endosulfan sulfate [35]; used to control ectoparasites on farm animals and pest [36]. The concentration (0.062) of endosulfan II was observed only in Suleja and below the maximum residual limit. Endrin aldehyde is observed only in Borgu (0.07 mg/kg) and above the maximum residual limit. All other isomers of cyclodienes were either zero or below their respective detection limits.

DDE is a fat soluble; endocrine disruptor [37]; weak anti-androgen [38]; neurotoxic, cause oxidative stress and damage brain's dopaminergic system; exposure link to Alzheimer's and Parkinson disease in human [39]. Table 3 shows the mean concentration (mg/kg) of the four isomers of dichloro diphenylethene in all five towns. The concentration of DDE was only observed in Bida. All other isomers and in all other

towns were below their respective detection limit. However, the concentration of DDE observed in Bida is higher than the maximum residual limit. DDT is reductively dechlorinated to DDD and dehydrochlorinated to DDE [40], generally by the action of microorganism [41] and the metabolites are more stable and persistent than the parent compound [40]. The residue level of DDE is a reflection of applications.

Table 4 presents the mean level (mg/kg) of hexachlorocyclohexane in melon. Only  $\lambda$ -BHC was detected in three sites – Bida, Borgu and Saki. The highest  $\lambda$ -BHC (mg/Kg) is observed in Borgu (0.31) followed by Bida (0.26) and the lowest in Saki (0.07). These concentrations were higher than maximum residual limit of 0.05 as stipulated by EU.

Table 5 shows the overall mean concentrations (mg/kg) of the heavy metals studied in all the five locations. The overall mean concentrations of all the metals in a decreasing order for every locations are as follows: Bida > Borgu > Saki > Suleja. Melon sample from Mokwa was free of organochlorine compounds.

**TABLE 3.** Mean levels (mg/kg) of dichloro diphenylethene in melon seed

OCPs	Bida	Borgu	Mokwa	Saki	Suleja	MRL
p, p' -DDD	<0.082	<0.082	<0.082	<0.082	<0.082	0.05
p,p' -DDE	0.17±0.00	<0.040	<0.040	<0.040	<0.040	0.05
p,p' -DDT	<0.078	<0.078	<0.078	<0.078	<0.078	0.05
Methoxychlor	<0.405	<0.405	<0.405	<0.405	<0.405	0.01

**TABLE 4.** Mean level (mg/kg) of hexachlorocyclohexane in melon seed

OCPs	Bida	Borgu	Mokwa	Saki	Suleja	MRL
$\alpha$ -BHC	<0.063	<0.063	<0.063	<0.063	<0.063	0.05
$\beta$ -BHC	<0.094	<0.094	<0.094	<0.094	<0.094	0.05
$\lambda$ -BHC	0.26±0.00	0.31±0.01	<0.057	0.07±0.01	0.01±0.00	0.05
$\delta$ -BHC	<0.017	<0.017	<0.017	<0.017	<0.017	0.05

**TABLE 5.** Total mean levels (mg/kg) OCPs in melon seed of the selected locations

Bida	Borgu	Mokwa	Saki	Suleja
0.47±0.01	0.40±0.01	ND	0.14±0.01	0.07±0.01

## CONCLUSION

Organochlorine pesticides residues and five metals in melon seed collected from five towns in Nigeria were investigated. The study revealed the occurrence of pesticides residue examined. The overall metal content per site of the studied elements in the selected sites was determined and it was in the following decreasing order: Mokwa > Bida > Suleja > Borgu > Saki. The mean metal concentrations was in the following decreasing order: Pb > Zn > Ni > Co > Cd. With exceptions of locations where Ni and Pb were below detection limit, the concentrations of Pb, Cd and Ni in other locations were above WHO/FAO recommended limit. Concentrations of Zn and Co were below WHO/FAO limits.

Generally, out of seventeen isomers of chlorinated organic compounds analyzed only four isomers were detected in all, two isomers of cyclodienes, one isomer each from dichloro diphenylethenes and hexachlorocyclohexane. The overall OCPs content per site of the studied elements in the selected sites was determined and it was in the following decreasing order: Bida > Borgu > Saki > Suleja. OCPs were not detected in melon samples obtained from Mokwa. With exception of endosulphan II, endrin aldehyde, heptachlor, DDE and  $\lambda$  – BHC were above their respective maximum residual limit.

To prevent or minimize long term human exposure and or inhalation to OCPs and heavy metals especially the farmers and consumers of melon. This could be done through environmental management, proper assessment and remediation of contaminated areas and maintain heavy metals as slow as possible. Future environmental monitoring is highly recommended. Continuous education and training should be provided to the farmers, emphasizing on the environmental implications of their use and exposure to pesticide residues.

## ABBREVIATION

BHC	Benzene hexachloride
ECD	Electron Capture Detector
Endrin CHO	Endrin Aldehyde
EU	European Union
Endosul	Endosulfan
FFDCA	Federal Food, Drug and Cosmetic Act
ND	Not detected
OCPs	Organochlorine Pesticides Residue
p,p'-DDD	Para, para-dichlorodiphenyldichloroethane
p,p''-DDE	Para, para-dichlorodiphenylchloroethylene
p,p''-DDT	Para, para-dichlorodiphenyltrichloroethane

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#### Persian Abstract

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#### چکیده

چندین کشور جهان با سطح بحران امنیت حاد مواد غذایی و سوء تغذیه روبرو هستند که نیاز به توجه فوری دارند. هندوانه و خربزه بسیار سرشار از پروتئین، روغن، مواد معدنی، ویتامین‌ها و منبع انرژی خوبی است. در نتیجه آلودگی بالای خربزه با فلزات سنگین و باقیمانده‌های سموم دفع آفات انسان و اکوسیستم را تهدید می‌کند. سموم دفع آفات ارگانوکلرین (OCPs) و فلزات کمیاب در خربزه به دست آمده از پنج شهر بزرگ نیجریه انجام شد. از ابزارهای تحلیلی برای تجزیه و تحلیل OCPهای استخراج شده از دیکلرومتان و نمونه‌های خربزه هضم‌شده به ترتیب استفاده شد. محتوای کلی فلزات در هر سایت از عناصر مورد بررسی در سایت‌های منتخب مشخص شد و به ترتیب کاهشی زیر است: Saki > Borgu > Suleja > Bida > Mokwa. میانگین غلظت فلزات به ترتیب در حال کاهش بود: سرب > روی > نیکل > Cd > Co. به استثنای مکان‌هایی که نیکل و سرب کمتر از حد تشخیص بودند، غلظت سرب، کادمیوم و نیکل در سایر مناطق بالاتر از حد توصیه شده WHO / FAO بود. غلظت روی و شرکت زیر حد WHO/FAO بود. از ۱۷ ایزومر OCPها که مورد تجزیه و تحلیل قرار گرفتند، تنها پنج ایزومر شناسایی شدند. محتوای کلی OCP در هر سایت از عناصر مورد مطالعه در سایت‌های منتخب مشخص شد و به ترتیب در حال کاهش بود: Bida > OCP > Suleja > Saki > Borgu در نمونه‌های تخم هندوانه و خربزه به دست آمده از Mokwa تشخیص داده نشد. به استثنای اندوسولفان نوع دو، آندرین آلدهید، هپتاکلر، DDE و BHC -λ بالاترین حد باقی‌مانده مربوطه را داشتند. نظارت و آموزش محیط زیست بسیار توصیه می‌شود.

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