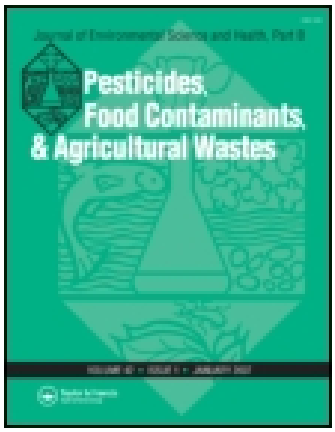

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Residue levels of organochlorine pesticides in cattle meat and organs slaughtered in selected towns in West Shoa Zone, Ethiopia

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Residue levels of organochlorine pesticides (OCP) in a total of 90 cattle samples comprising meat, liver and kidney collected from carcasses slaughtered in six towns in West Shoa Zone, Ethiopia, (Ambo, Guder, Ginchi, Gedo, Holeta and Tikur Inchini), have been determined. The pesticides were extracted by solid phase extraction (SPE) and quantification was carried out using gas chromatography-mass spectrometry (GC-MS). A good linearity ($r^2 > 0.998$) was found in the range 0.001–7.00 mg/kg for the samples studied. Most of the pesticides had recoveries in the range 81–99% and values of relative standard deviation (RSD) <7.2% for repeatability and reproducibility, showing good accuracy and precision of the method. The concentration level of the studied organochlorines followed the order: p, p' dichloro-diphenyl-trichloroethane (DDT) > endosulfan>o,p′-DDT >lindane>dieldrin>endrin>aldrin>chlorothanolin while the order of contamination in the analyzed organs was liver > kidney > meat. Heat treatment of the meat, kidney and liver samples (boiling for 90 min.) produced an overall reduction of 62.2%, 44.5%, 37.7%, 29%, 31%, 34.3% and 30.8% in lindane, o, p′-DDT, endosulfan, p, p′-DDT, chlorothanolin, aldrin, dieldrin, and endrin, respectively. Although the residual contents of the organochlorines detected in all the contaminated samples analyzed from the six cities were below the respective maximal permissible levels set by international organizations, samples from Holeta town were more contaminated and may necessitate effective monitoring as bioaccumulation of these residues may pose health problems in human beings.

Keywords: Organochlorine pesticide, residue, meat, liver, kidney, contamination, heat treatment, GC-MS.

Introduction

It is well known that the widespread use of organochlorine pesticides in agriculture has produced serious problems due to their capacity to accumulate in the food chain.[1] Organochlorine pesticides have been used in Jordan for over 50 years for both agricultural and public health purposes.[2] Pesticides have been used in the public health sector for disease vector control and in agriculture to control and eradicate crop pests for the past several decades in Ghana.[3] Organochlorine compounds are highly lipophilic and can accumulate in fat-rich food such as meat and milk.[4] Pesticides are introduced into cattle mainly through fodder, pasture or contaminated water because they are used for household and public purposes.[5] Meat may contain high levels of pesticides residues in the tissues following cattle dipping or vector control or when they feed on feedstuffs contaminated with these chemicals. Because these chemicals are toxic to living organisms, increased accumulation in the food chain may pose serious health hazards to the general populace.[6] Levels of 15 organochlorine pesticides in samples of liver, kidney and adipose tissues from sheep (male and female) gathered from slaughter houses in Amman/Jordan have been determined.[7] Darko and Acquaah[3] have reported the concentrations of organochlorine pesticides (Lindane, Aldrin, Diedrin, Endosulfan, DDT and DDE) residues in beef samples from the Kumasi and Buoho abatours in Ghana. Organochlorine pesticides residues have been determined in a total of 270 meat samples comprising the muscle, liver and kidney from carcasses of camel, cattle and sheep slaughtered in Sharkia province, Egpyt.[8] Other studies on monitoring the levels of organochlorine pesticide residues in different matrices like adipose tissues,[9] human and sheep milk[10–12], fish[13–14] and human bone marrow[15] have also been reported. Pesticides residues in water, plants and grasses may be ingested by herbivores and eventually find their way into meat and milk.[16]

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Ethiopia is the second most populous country in Africa with a largely agricultural based economy. In Ethiopia, organochlorine pesticides have been used for several decades for different purposes. According to a report by Ethiopian Ministry of Health, Ethiopia uses approximately 400 tons of active-ingredient dichloro-diphenyl-trichloroethane (DDT) for indoor residual spraying (IRS) per year.[17] Vast quantities of chlorinated pesticides such as aldrin, dieldrin, chlordane, endrin, heptachlor, mirex, toxaphene and hexachlorobenzene (HCB) have been used for crop protection and control of disease-transmitting insects in Ethiopia as evidenced by a significant amount of such pesticides found as stockpiles and wastes (obsolete pesticides) together with other pesticides in some parts of Ethiopia during the inventory phase of the national implementation plan (NIP) preparation.[18] Although most of the organochlorine pesticides are no longer in use, they are still being found as residues and they are occurring in food now as a result of environmental contamination.

The West Shoa Zone of Ethiopia is a predominantly agricultural area and the use of organochlorine pesticides in farmlands may lead to their accumulation in animal feedstuff resulting also in their possible accumulation in animal meat. As the effects of these organochlorine pesticides in the food chain have not been assessed, it is essential to monitor residue levels of these pesticides in the food chain. Since Ethiopians are traditionally consumers of raw meat, there is great concern that the accumulation of organochlorine pesticides residues in meat and meat products may create serious problems for human health.

The aim of this study is to assess the extent of contamination of organochlorine compounds in cattle slaughtered in the West Shoa Zone, Ethiopia in order to ensure its safety for human consumption as well as study the effect of heat treatment of meat on the residual levels of such organochlorines.

Materials and methods

Sampling

A total of 90 samples (5 each from meat, liver and kidney) were collected on the day of slaughtering from 15 carcasses from different slaughterhouses in Ambo, Guder, Ginch, Holeta, Tukur Inchini, and Gedo towns in West Shoa Zone, Ethiopia (Fig 1). The tissues were collected on 5 occasions over a period of three months (from March to May, 2008) from different butcher houses. Each individual tissue sample (~500g for meat and ~200g for liver and kidney) were separately packaged in different aluminum foils, placed in an iced-chest containing ice and transported to the laboratory where they were stored at 4°C until analysis. Samples were subjected to analysis within 24 hr from their arrival.

Pesticides and reagents

Pesticide standards (DDT and its isomers (o, p-DDT and p, p-DDT), Aldrin, Dieldrin, Endrin, γ-HCH (lindane), Endosulfa-I and Chlorothanolin) and bond elute C-18 cartridge were purchased from Dr. Ehrensdorfer (Augsburg, Germany). Anhydrous sodium sulfate, petroleum ether, diethyl ether, dichloromethane, n-hexane, acetonitrile (HPLC grade) were purchased from Merck (Darmstadt, Germany). All solvents were of pesticide-residue grade and subjected to a solvent purity test for residue analysis suitability.

Extraction of pesticide residue

An amount measuring 50g of each meat sample was ground using a meat blender at high speed with 100g anhydrous sodium sulfate for 2 mins. Amounts measuring 150 mL, 100 mL and 100 mL petroleum ether respectively were added to the sample in three successive steps as described in the Pesticide Analytical Manual.[19] The samples were filtered with a vacuum pump after each extraction and the solvent evaporated on a rotary evaporator at 40° C until dryness.

Partitioning of the extract

Partitioning of the extracted samples was carried out according to the method of Association of Official Analytical Chemist.[20] The extracted sample was transferred into a 100 mL separatory flask and a mixture of 80 mL n-hexane and 20 mL of acetonitrile was added with vigorous shaking for 1 min. After separation, the acetonitrile layer was collected and anhydrous sodium sulfate was added to remove any moisture. Another 20 mL acetonitrile was added to the n-hexane layer and the partitioning step repeated three times. Finally, the n-hexane portion was discarded while the acetonitrile portion was evaporated on a rotary evaporator to a volume of 10 mL and ready for cleanup using solid phase extraction (SPE) with C-18 bond cartridge.

Clean up of the extract

The extract was transferred into a glass chromatographic column containing bond elute C-18 cartridge, which has been topped with a layer of anhydrous sodium sulfate.[21] The column was first preconditioned by rinsing with petroleum ether and the extracted sample was then transferred into the column. The column was eluted with 200 mL eluent (10% diethyl ether + 90% petroleum ether) followed by a second elution with 100 mL of another eluent (1% acetonitrile + 29% n-hexane + 70% methyl chloride). The collected eluants were combined and then concentrated on a rotary evaporator and dissolved in n-hexane to a volume less than 10 mL. An aliquot of each extract was transferred

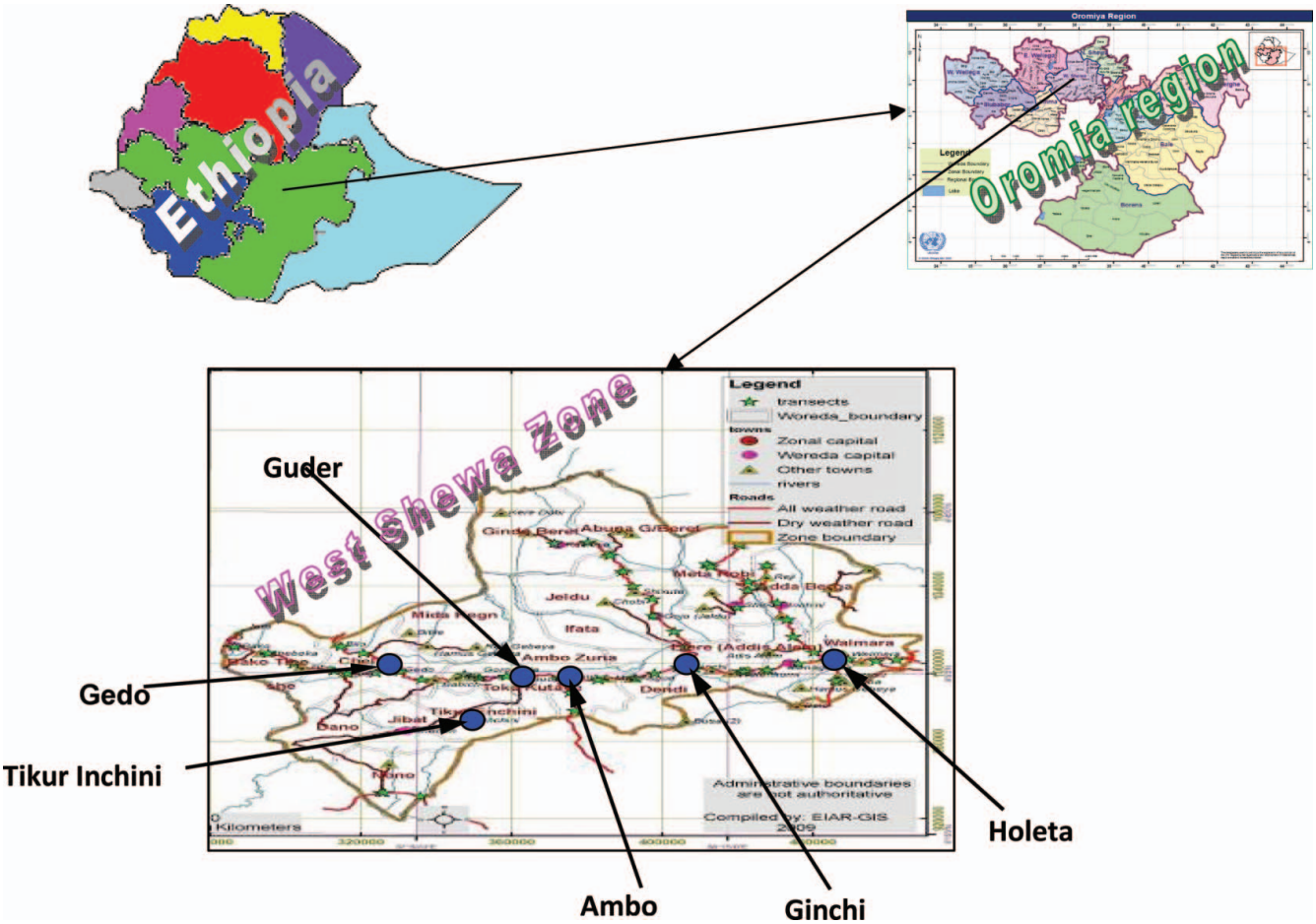

Fig. 1. Location map of sample collection sites (color figure available online).

into 2 mL vial, ready for analysis by gas chromatography-mass spectrometry (GC-MS).

Heat treatment of meat samples

The effect of heat treatment using normal kitchen processing procedure (boiling in water for 90 min.) on the concentrations of residual pesticides (Lindane, Aldrin, Diedrine, Endrine, Chlorothaolin, Endolsulfan and DDT) was determined in all the samples (meat, liver and kidney) after extraction following the procedure already described.

Analytical methods

Determination of residual concentration of organochlorine pesticides. Organochlorine residues were determined by analysis of samples using a gas chromatography-mass spectrometry (Perkin-Elmer Clarus 600 model, USA) with selective ion detector (quadrupole) and a fused silica capillary incorporating a proprietary phase-5% phenyl, 95% methylpolysiloxane (30 m x 0.32 mm i.d; film thickness 0.25 μm). The GC was operated under the following conditions: initial temperature 60°C, held for 5 min. and ramped to 280°C at 15 min, being held for 6 min. The carrier gas (helium) was in constant flow mode at 1.0 mL/min. Splitless injection of a 1.0 μL volume was carried out at 250°C with the purge valve on at 2 min. The mass spectrometer was operated in electron ionization (EI) mode with impact ionization voltage 70 eV, a transfer line temperature of 280°C, ion source 280°C, solvent delay 10.5 min, full scan time of 0.2 sec, inter scan delay of 0.05 sec. and selected ion monitoring (SIM) mode.

Method validation. Validation of the method was done by calculating percentages recoveries of each standard organochlorine pesticide. A spiking solution of 0.1, 1.0, 3.0, 5.0 and 7.0 ppm containing all eight organochlorine pesticides were prepared in acetonitrile. Method blanks were determined by taking the blanks through the entire measurement process.

Calibration standard curves were created and organochlorine pesticide residues were quantitatively determined by comparison with the standard solutions under the identical gas chromatography-mass spectrometry conditions. The reliability of analytical method was examined by analyzing the fortified and tested samples with known

Table 1. Main ion fragments of pesticides detected by GC-MS.

Pesticides	*Main ion fragments (m/z)*			
P,p′ DDT	75	165	235	354
O,p′ DDT	75	165	235	354
Endosulfan (α)	170	195	241	406
Chloronthanolin	109	266	270	
Aldrin	66	79	263	364
Dieldrin	79	108	263	380
Eldrin	67	81	263	380
Lindane	109	181	219	290

quantities of tested pesticides after extraction, clean up and analysis.

Linearity range, mean recovery, and limit of determination (LOD) were determined.

Statistical analysis

All values of residual pesticides were obtained as mean (n = 5) ± standard deviation (SD). Data were subjected to one-way analysis of variance (ANOVA) to determine the differences in organochlorine pesticides contents among different species analyzed. One tailed t-test was conducted to identify the significance of difference between the means of raw and cooked samples.

Results and discussion

Validation of the method

The OCPs were identified by their retention times and fragment ions (Table 1) along with data library of National Institute of Standards and Technology (NIST). The gas chromatogram for the residual pesticide in liver from Holeta sample is presented in Figure 2 while the mass spectrum of standard aldrin pesticide is shown in Figure 3. The efficiency of the extraction method used in this work was evaluated by means of recovery studies with meat samples fortified at three different levels (Table 2). Method blank analysis showed no cross contamination as no significant peaks were observed. The performance of the method was evaluated and linearity, recovery and limit of determination (LOD) were determined. A good linearity ($r^2 > 0.998$) was found in the range 0.001–7.0 mg/kg for the samples studied. Most of the pesticides had recoveries in the range 81–99% and values of relative standard deviation (RSD) < 7.2% for repeatability and reproducibility, showing good accuracy and precision of the method.

Determination of pesticides residues

The results of organochlorine pesticides analysis from meat, liver and kidney samples are presented in Tables 3, 4 and 5. Out of 90 samples analyzed, 75 (83.3%) and 90 (100%) were positive for o, p′-DDT, p, p′-DDT, in the meat, liver and kidney samples, 60 (66.7%) and 90 (100%) were positive for endusufan-1 in meat and both liver and kidney samples respectively, 60 (66.7%) were positive for lindane in the meat sample while 45 (50%) were positive for chloronthalin, and dieldrin in the three samples. A 50% incidence of aldrin and eldrin were detected in liver, and 33.3% in kidney samples. Lower incidence of aldrin (33.3%) and endrin (16.7%) were also detected in the meat sample.

DDTs (dichloro-diphenyl-trichloroethane)

It has been reported that the frequency of occurrence of DDT in meat is higher in the developing countries than in

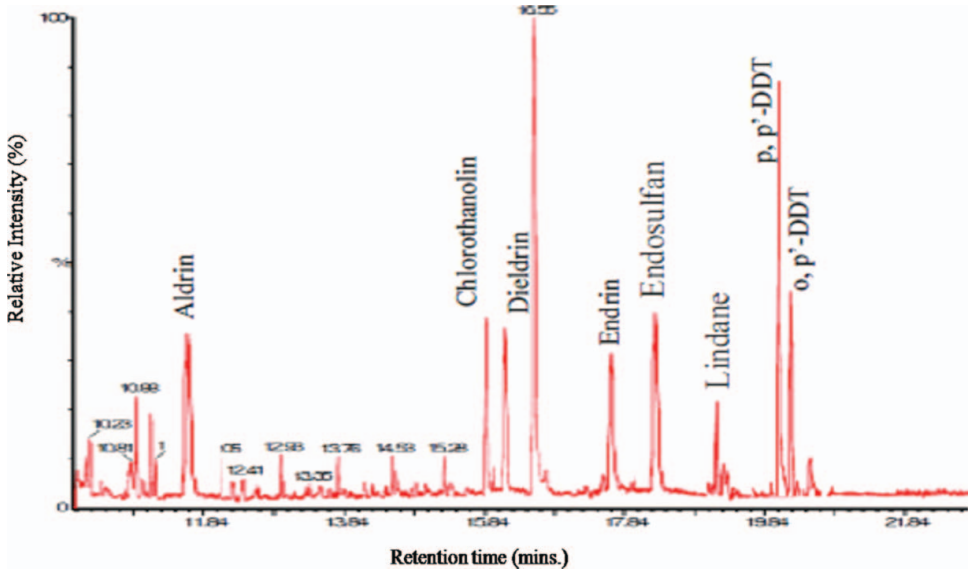

Fig. 2. Gas chromatogram of pesticides residues in Holeta liver sample (color figure available online).

Table 2. Percentage recoveries, LOD, Linear range, Regression coefficient (r^2) and RSD of organochlorine pesticides.

Compounds	*Spiked level (mg/kg)*	*Mean recovery (%)*	*RSD* (%) (n = 3)*	*LOD* (mg/kg)*	*Linear range (mg/kg)*	*Regression coefficient (r^2)*
o, p′-DDT	0.1	85.7	3.6	0.0002	0.1–7	0.991
	1	89.6	3.4			
	3	89.8	5.1			
	5	92.5	5.2			
	7	90.6	3.9			
p, p′-DDT	0.1	89.9	5.6	0.0003	0.1–7	0.998
	1	95.2	3.6			
	3	96.4	4.1			
	5	92.4	3.8			
	7	99.2	3.7			
Endosulfan-I	0.1	87.8	5.6	0.0001	0.1–7	0.994
	1	92.5	1.4			
	3	92.8	2.4			
	5	93.4	7.2			
	7	94.7	5.6			
Chlorothanolin	0.1	88.8	6.3	0.0001	0.1–7	0.999
	1	86.4	7.2			
	3	87.5	6.2			
	5	80.9	4.2			
	7	88	4.1			
Aldrin	0.1	85.7	4.7	0.0001	0.1–7	0.996
	1	92.7	5.2			
	3	90.1	5.1			
	5	89.2	6.5			
	7	92.7	2.7			
Dieldrin	0.1	88.7	4.2	0.0001	0.1–7	0.998
	1	92.1	4.7			
	3	93.3	3.7			
	5	95.2	5.2			
	7	96.1	4.9			
Endrin	0.1	83.2	2.4	0.0001	0.1–7	0.997
	1	85.7	1.7			
	3	82.9	3.4			
	5	86.8	3.1			
	7	87.1	3.4			
Lindane	0.1	92.1	3.5	0.0001	0.1–7	0.999
	1	89.7	4.2			
	3	94.1	2.5			
	5	88.9	3.8			
	7	90.7	2.7			

*RSD: Relative Standard Deviation' LOD: Limit of Detection.

more developed ones, such as Canada which reported only 21% of DDT in analyzed fat samples of different slaughtered animals.[22] In this work the frequency of occurrence of o,p'-DDT (83.3%) and p, p' DDT(100%) in meat samples are higher than those reported in Canadian and Egyptian[10] meats but are similar to the reported frequency of 90% and 100% in bovine and lamb meats respectively in Bagdad,[23] 90% in bovine meat in Nigeria,[24] 88% in meat and meat products in Spain[25] and 100% in beef samples from Ghana.[3] However, much higher DDTs concentrations had been reported in meat analyzed in Thailand,[26] India[27] and Belarus.[28] The higher frequency of DDT detection in this work may be due to DDT's use for malaria control or its persistence in the environment. Mean residual concentrations of o, p′-DDT and p, p′-DDT (3.83 mg/kg, 5.16 mg/kg and 4.51mg/kg) were obtained in meat, liver and kidney samples from the towns and cities studied. Significant variation in the residual concentration of the pesticides among the three organs analyzed (meat, liver and kidney) were observed, with the dominant pesticide residue (DDT's) found mostly in liver and kidney. This is mainly because liver and kidney are detoxification organs in the animal's body and tend to accumulate toxic substances. However, the various amounts of residual pesticides found

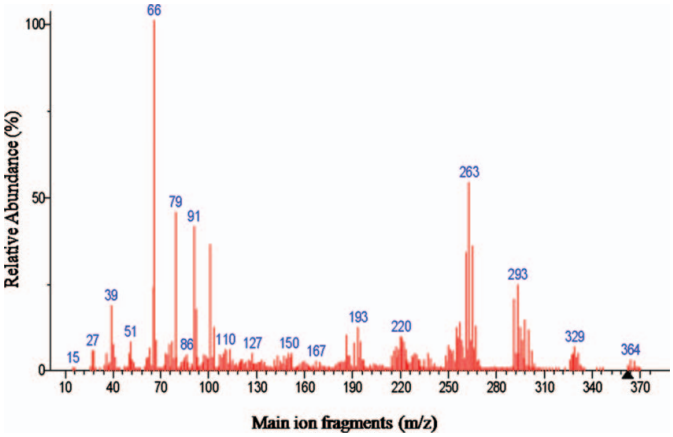

Fig. 3. Mass spectrum of aldrin standard pesticide (color figure available online).

are slightly lower than the maximum concentration level set by FAO/WHO for DDT in meat (5 mg/kg) but comparable with those reported in meat, liver and kidney samples from Egypt[8] and Jordan.[12] However, much higher DDTs concentrations had been reported in meat analyzed in Thailand,[26] India[27] and Belarus.[28]

Endosulfan-I

Endosulfan-I was detected in 66.7% of meat samples analyzed while it was positive in 100% of liver and kidney samples. Darko and Acquaah[3] had reported a higher incidence of endusulfan-I (90%) in meat samples analyzed in Ghana. The result in this work showed that liver and kidney are relatively more contaminated with endosulfan-I than the meat sample. However, the concentration is well below the maximum permissible level set by FAO/WHO (0.2 mg/kg). The relatively high incidence of endosulfan in liver and kidney samples is due to the detoxification function of these organs in the animal body which tend to accumulate toxic substances.

Lindane (gamma-hexachlorocyclohexane, γ-HCH)

Lindane was detected in 66.7% of each meat, liver and kidney samples analyzed. Studies have shown that lindane had been detected in 100% of analyzed lamb and pork meat products in Spain.[25] It has also been reported in 90% of analyzed meat and organs of cattle in Nigeria.[24] But it was detected in <10% of analyzed animal fat samples in Canada.[22] Lindane level in this study was generally low in all the analyzed organs with the highest level (0.14 mg/kg) detected in the liver sample obtained from Holeta. These results are in agreement with those reported from Vietnam,[29] India[27] and the Solomon Islands,[30] although higher levels have also been reported in meat sample from Belarus.[28]

Aldrin

Aldrin was detected in 33.3% of meat and 50% of both liver and kidney samples in this study. Although aldrin had been reported in 100% and 80% in sheep kidney and liver respectively from Jordan,[7] 66% in bovine meat and organs from Nigeria,[24] 33.3% and 43.3% in liver and kidney samples analyzed in Egypt[8] respectively, 30% in meat samples from Ghana,[3] it was only detected in <2% of the tested food samples from Taiwan.[31] No detectable level of aldrin was found in ruminant food samples from Poland.[32] The mean concentration of aldrin in the meat, liver and kidney samples obtained in this study is similar to those reported from Egypt,[8] Vietnam,[29] Italy[33] but higher concentrations have been found in samples reported from Nigeria.[24] However, the concentration of aldrin found in this work is well below the maximum permissible level of 0.2mg/kg set by FAO/WHO.

Dieldrin

Dieldrin was detected in 50% of each analyzed meat, liver and kidney samples. Alawi and Al-Hawadi[7] had detected dieldrin in 53% of the male sheep kidney and liver samples from Jordan. Higher incidence (100%) had been detected by

Table 3. Concentrations of organochlorine pesticides in meat.

	Concentrations (mg/kg)					
Compounds	*Ambo*	*Guder*	*Ginchi*	*Gedo*	*Holeta*	*TikurInchini*
o, p′-DDT	0.29 ± 0.001	2.06 ± 0.012	nd	0.43 ± 0.002	3.24 ± 0.042	1.83 ± 0.021
p, p′-DDT	2.04 ± 0.031	4.12 ± 0.022	1.5 ± 0.001	0.37 ± 0.011	4.32 ± 0.003	2.74 ± 0.001
Endosulfan-I	0.03 ± 0.005	0.03 ± 0.003	nd	nd	0.06 ± 0.004	0.01 ± 0.002
Chlorothanolin	0.001 ± 0.0004	nd	0.003 ± 0.001	nd	0.004 ± 0.001	Nd
Aldrin	nd	0.001 ± 0.0002	nd	nd	0.012 ± 0.002	Nd
Dieldrin	nd	nd	0.001 ± 0.0002	0.01 ± 0.006	0.04 ± 0.003	Nd
Endrin	nd	nd	nd	0.011 ± 0.0004	nd	Nd
Lindane(ã-HCH)	nd	0.02 ± 0.003	nd	0.01 ± 0.004	0.05 ± 0.001	0.002 ± 0.001

*Values are reported as mean (n = 5) ± standard deviation (SD); nd: non detected.

Table 4. Concentrations of organochlorine pesticides in liver.

	*Concentrations (mg/kg)					
Compound	*Ambo*	*Guder*	*Ginchi*	*Gedo*	*Holeta*	*Tikur*
o, p′-DDT	0.49 ± 0.001	2.35 ± 0.021	nd	1.22 ± 0.001	3.74 ± 0.002	2.15 ± 0.012
p, p′-DDT	4.16 ± 0.041	4.35 ± 0.022	2.93 ± 0.011	1.52 ± 0.032	4.62 ± 0.021	3.23 ± 0.001
Endosulfan-I	0.04 ± 0.001	0.07 ± 0.001	0.02 ± 0.001	0.12 ± 0.031	0.18 ± 0.041	0.012 ± 0.001
Chlorothanolin	0.003 ± 0.001	nd	0.005 ± 0.001	nd	0.006 ± 0.001	nd
Aldrin	nd	0.004 ± 0.001	nd	0.01 ± 0.031	0.016 ± 0.006	nd
Dieldrin	nd	nd	0.01 ± 0.005	0.02 ± 0.002	0.05 ± 0.008	nd
Endrin	nd	nd	0.003 ± 0.001	0.04 ± 0.001	0.007 ± 0.001	nd
Lindane(ã-HCH)	nd	0.03 ± 0.006	nd	0.07 ± 0.001	0.14 ± 0.005	0.005 ± 0.001

*Values are reported as mean (n = 5) ± standard deviation (SD); nd = none detected.

Osibanjo and Adeyeye[24] in meat and organs of cattle and goat slaughtered from Nigeria. In contrast lower detection incidence (<10%) had been detected from various slaughter animals in Canada[22] and in meat and meat products from Spain.[25] Although the highest concentration (0.05 mg/kg) of dieldrin in this study was detected in the liver sample, it was much lower than those reported by Alawi and Al-Hawadi (0.73 mg/kg fat liver and 0.19 mg/kg fat kidney).[7]

Endrin

Endrin was detected in 16.7%, 50% and 33% of meat, liver and kidney samples analyzed in this study respectively. Endrin was detected in 27% of kidney and liver from male sheep from slaughter houses in Jordan.[9] Sallam and Morshedy[8] had detected endrin in 20% of both liver and kidney of cattle carcasses slaughtered in Egypt but none was detected in the muscle. Similar reports by Herrera et al.[25] in Spain could not detect endrin in any of the analyzed beef and lamb meat. In this study, although the residual concentration of endrin was higher in kidney (0.025 mg/kg) than in liver (0.007 mg/kg), it was almost non-detected in the meat sample. These values though comparable to those reported by Alawi and Al-Hawadi[7] in liver and kidney samples were lower than the maximum residual levels set by FAO/WHO for endrin (0.05 ppm).

Chloronthanolin

Chlorothanolin was detected in 50% of meat, liver and kidney samples respectively in this study. The mean concentrations of chlorothanolin were relatively higher in liver (0.006 mg/kg) followed by kidney (0.005 mg/kg) and meat (0.004 mg/kg) samples.). Doong et al.,[31] had reported similar low levels of chlorothanoloin in meat and meat products. The low concentrations of chlorothanolin reported in this work were below the FAO/WHO (0.02mg/kg) maximum permissible limit.

Incidence of contamination with different organochlorines

Among various organochlorine pesticides determined in this study DDTs (p,p′-DDT and o,p′-DDT), endosulfan-I, and lindane are the most prominently noticed compounds as they were detected at high incidence of >50%. Dieldrin and chlorothanolin were detected in 50% of the samples while aldrin and endrin were detected only in 44.4% and 33.3% of the samples respectively. Generally, the incidence

Table 5. Concentrations of organochlorine pesticides in kidney.

	*Concentration (mg/kg)					
Compound	*Ambo*	*Guder*	*Ginchi*	*Gedo*	*Holeta*	*Tikur*
o, p′-DDT	0.32 ± 0.004	2.31 ± 0.005	nd	0.95 ± 0.013	3.62 ± 0.001	1.96 ± 0.011
p, p′-DDT	3.06 ± 0.027	4.24 ± 0.042	2.42 ± 0.008	0.86 ± 0.012	4.43 ± 0.024	2.82 ± 0.012
Endosulfan-I	0.032 ± 0.003	0.052 ± 0.008	0.012 ± 0.001	0.08 ± 0.001	0.09 ± 0.013	0.011 ± 0.001
Chlorothanolin	0.002 ± 0.001	nd	0.004 ± 0.001	nd	0.005 ± 0.001	Nd
Aldrin	nd	0.002 ± 0.001	nd	0.009 ± 0.001	0.013 ± 0.005	Nd
Dieldrin	nd	nd	0.008 ± 0.001	0.012 ± 0.001	0.042 ± 0.004	Nd
Endrin	nd	nd	nd	0.025 ± 0.005	0.005 ± 0.001	Nd
Lindane (ã-HCH)	nd	0.021 ± 0.006	nd	0.042 ± 0.001	0.071 ± 0.006	0.004 ± 0.001

*Values are reported as mean (n = 5) ± standard deviation (SD).

of contaminations of the examined meat, liver and kidney samples by the organochlorines followed the order of p, p′-DDT >endosulfan> o, p′-DDT >lindane>dieldrin = chlorothanolin>aldrin>endrin as shown in Figure 4. Similar order for the organochlorine contamination has been reported by Sallam and Morshedy[8] and Falandysz and Kannan[32] in cattle slaughtered from Egypt and Poland respectively.

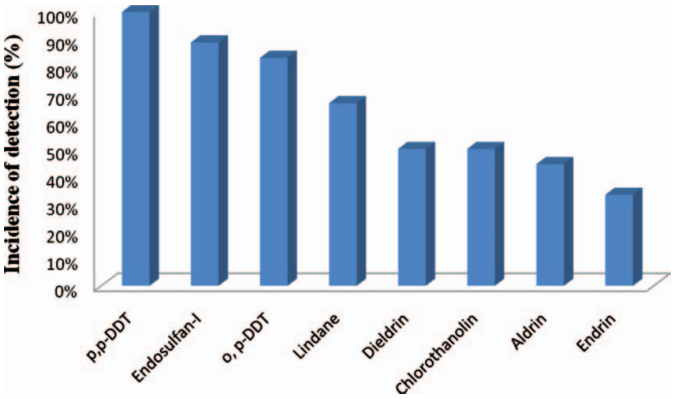

Fig. 4. Incidence of detection of OCPs in meat, liver and kidney samples analyzed (color figure available online).

Variations of organochlorine concentration among the different organs

Among the various organs analyzed, liver samples generally showed the highest organochlorine concentration followed by kidney while the meat sample exhibited the lowest residual concentrations. The analysis of variance

Table 6. Effect of heat treatment (boiling for 90 min) on the residual contents of organochlorines in tissue samples.

		Mean (n = 5) ± SD (mg/kg)		
Pesticides	*Tissue samples*	*Before cooking*	*After cooking*	*Reduction (%)*
o,p′-DDT	Meat	2.535 ± 0.705	1.34 ± 0.30	47.1
	Liver	2.25 ± 0.10	1.32 ± 0.10	41.3
	Kidney	0.24 ± 0.01	0.055 ± 0.005	77.1
	Total	5.025 ± 0.805	2.715 ± 0.405	45.9
p, p′-DDT	Meat	3.43 ± 0.69	2.155 ± 0.085	37.2
	Liver	2.85 ± 0.38	1.745 ± 0.095	38.8
	Kidney	1.55 ± 1.23	0.98 ± 0.086	36.8
	Total	7.83 ± 2.30	4.88 ± 0.256	37.7
Endosulfan-I	Meat	0.04 ± 0.02	0.025 ± 0.005	37.5
	Liver	0.026 ± 0.014	0.016 ± 0.004	38.5
	Kidney	0.025 ± 0.015	0.0095 ± 0.0015	62.0
	Total	0.091 ± 0.049	0.0505 ± 0.0105	44.5
Chlorothanolin	Meat	—	—	—
	Liver	0.006 ± 0.003	0.0044 ± 0.001	26.7
	Kidney	0.004 ± 0.001	0.0027 ± 0.001	32.5
	Total	0.010 ± 0.002	0.0071 ± 0.005	29.0
Aldrin	Meat	0.001 ± 0.0002	0.0007 ± 0.0001	30.0
	Liver	0.016 ± 0.006	0.011 ± 0.005	31.5
	Kidney	0.013 ± 0.005	0.009 ± 0.002	30.7
	Total	0.030 ± 0.0112	0.0207 ± 0.0071	31.0
Dieldrin	Meat	—	—	—
	Liver	0.05 ± 0.008	0.032 ± 0.002	36.0
	Kidney	0.02 ± 0.004	0.014 ± 0.0014	30.0
	Total	0.07 ± 0.004	0.046 ± 0.0034	34.3
Endrin	Meat	—	—	—
	Liver	0.027 ± 0.007	0.019 ± 0.006	29.6
	Kidney	0.0185 ± 0.001	0.0155 ± 0.003	27.0
	Total	0.0455 ± 0.008	0.0315 ± 0.009	30.8
Lindane	Meat	0.022 ± 0.005	0.009 ± 0.001	59.1
	Liver	0.0725 ± 0.001	0.026 ± 0.008	64.1
	Kidney	0.042 ± 0.001	0.016 ± 0.004	61.9
	Total	0.1365 ± 0.007	0.051 ± 0.013	62.6

SD: standard deviation.

Table 7. Average concentrations (mg/kg) of organochlorine pesticides in meat, liver and kidney samples after cooking.

	Average concentrations (*) after cooking (mg/kg)		
Pesticides	*Meat*	*Liver*	*Kidney*
o, p′-DDT	1.34 ± 0.30	1.32 ± 0.10	0.055 ± 0.005
p, p′-DDT	2.16 ± 0.085	1.75 ± 0.095	0.98 ± 0.086
Endosulfan-I	0.025 ± 0.005	0.016 ± 0.004	0.0095 ± 0.0015
Chlorothanolin	nd	0.0044 ± 0.001	0.0027 ± 0.001
Aldrin	0.0007 ± 0.0001	0.011 ± 0.005	0.009 ± 0.002
Dieldrin	nd	0.032 ± 0.002	0.014 ± 0.0014
Endrin	nd	0.019 ± 0.006	0.0155 ± 0.003
Lindane(ã-HCH)	0.009 ± 0.001	0.026 ± 0.008	0.016 ± 0.004

*Values are reported as mean (n = 5) ± standard deviation (SD); nd: none detected.

(ANOVA) test was conducted to compare the differences in organochlorine levels among the organs. All of the determined organochlorines showed high significant difference ($P < 0.001$) in their concentrations among the three analyzed organs.

Effect of heat treatment on the residual concentration of organochlorines

It has been proved that the technological and kitchen processes can partially or fully remove or degrade organochlorine pesticide residues to other compounds that are often less toxic, which renders products safer for human consumption.[9,33,34,35] In this study, selected meat, liver and kidney samples were cooked by boiling in water for 90 min to determine the possible reduction in their residual contents of organochlorines. The result of heat treatment effect on the residual pesticides obtained in all the samples is shown in Table 6. There was significant reduction in the level of the organochlorine pesticides which varied from 26.7% to 77% in the various samples. The highest percentage reduction of 77% was recorded for o, p′-DDT in the kidney sample followed by lindane (64.1%) in liver and endosulfan-I (62%) in kidney sample. The effect of heat treatment on the residual concentration of organochlorine pesticides has been previously studied in various meat and meat products. The percentage reductions of organochlorine pesticide residues found in this study were similar to what had been reported by others. A mean reduction rate of 40.4%, 55.0%, 32.4%, 33.5%, and 29.2% had been detected for DDTs, lindane, dieldrin, aldrin and endrin respectively after cooking selected meat, liver and kidney samples in water for 90 min.[10] Bayarri et al.[37] reported a reduction rate of 44% for DDT after thermal processing of lamb meat cuts. A reduction rate of 60% in lindane content had been reported for cooked beef meat after heating at 115°c for 2hrs.[37] Also, a high reduction rate of 65% in lindane content had been reported in rabbit meat after boiling for 1.5 h.[38] Zabik et al.[36] also reported a significant reduction in DDT complex and dieldrin contents in fish fillets after heat treatment. The significant loss in the organochlorine pesticide residues in meat and organs after cooking (Table 7), could be attributed to the volatility of these compounds and to the elimination with the fat induced by high temperatures. These results indicated that cooking had significantly reduced the levels of contamination of o,p′-DDT in meat and liver to an average of 1.33 mg/kg and p,p′-DDT in the three organs to 1.63 mg/kg and other pesticides to only trace or non-detectable levels.

Conclusion

The residual concentrations of organochlorine pesticides (DDT, endosulfan, chlorothanolin, aldrin, dieldrin, endrin and lindane) detected from the examined meat and organs of cattle carcasses slaughtered in the selected towns in West Shoa Zone, Ethiopia, are lower than the maximal permissible limits set by WHO/FAO. Liver samples were more contaminated with the pesticides than the meat and kidney samples. The predominant organochlorine pesticides obtained in meat and organs were o, p′-DDT and p, p′-DDT, with the highest contamination observed in the Holeta samples. Moreover, efficient cooking could significantly reduce the residual concentration of the organochlorines in meat thereby posing no serious health problem but bioaccumulation can possibly reverse this.

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