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Organochlorine pesticide residues in camel, cattle and sheep carcasses slaughtered in Sharkia Province, Egypt

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Abstract

Organochlorine pesticide residues were determined in a total of 270 meat samples; comprising the muscle, liver, and kidney collected from 90 carcasses (30 each of camel, cattle and sheep) slaughtered in Sharkia Province, Egypt. All samples were analyzed for their residual contents of DDT compounds (DDTs), hexachlorocyclohexane isomers (HCHs), lindane (γ-HCH), aldrin, dieldrin, endrin, hexachlorobenzene (HCB), toxaphene, and chlordane compounds. The results indicated that 54.4% (49/90), 51.1% (46/90), 47.8% (43/90), 44.4% (40/90), 33.3% (30/90) and 15.6% (14/90) of the examined carcasses were contaminated with DDTs, HCHs, lindane, aldrin, dieldrin and endrin, respectively. The other contaminants (HCB, toxaphene, and chlordane) were only present in less than 10% of the analyzed carcasses. Amongst the three meat animal species examined, the incidence of contamination as well as the residual concentrations of all the pesticides detected in camel carcasses were lower than those detected for cattle and sheep. The contamination level of the studied organochlorines followed the order: DDTs > HCHs > lindane > dieldrin > aldrin > endrin > toxaphene > HCB > chlordane; while the order for the contamination in the analyzed organs was liver > kidney > muscle. Heat treatment of some selected samples (boiling for 1.5 h) produced overall reductions of 40.4%, 55.0%, 32.4%, 33.5%, 29.2%, 42.7% and 38.2% in DDTs, lindane, dieldrin, aldrin, endrin, toxaphene and HCB contents, respectively. The residual contents of the organochlorines detected in all of the contaminated samples analyzed from the three different species were well below the respective maximal permissible limits set by local or international organizations.

Keywords: Organochlorine pesticides; Carcasses; Muscle; Liver; Kidney; Heat treatment

1. Introduction

Egypt is the most populous country in the Arab world, and the second-most populous in Africa following Nigeria. The majority of the 77 million inhabitants of Egypt live in crowded cities and villages along the narrow green strip of land beside the River Nile and its north delta around the capital, Cairo. In this densely populated and limited area, about one million metric tons of commercial organochlorine pesticides were used and injected into the environment since the beginning of the pesticide evolution in Egypt (1952) up until 2003 (Mansour, 2004).

The cotton plant still represents the most important crop and a main element for the national economy of Egypt. Pests infesting cotton affect quality and quantity of the yield. Up until now, pesticides are considered one of the main elements of protecting this crop. In an area fluctuates between 700,000 and 800,000 acres, insecticides are applied by high pressure sprayers 3–5 times per season for controlling cotton leafworm, bollworm, and many other pests. Corn, rice, sugarcane plantations, as well as many different varieties of vegetable and fruit crops also consume a large quantity of different pesticides (insecticides, fungicides, herbicides, etc.) (Mansour, 2004). The

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reported major organochlorine pesticides used in Egypt during a 30-year period were toxaphene (1955–1961), endrin (1961–1981), DDT (1952–1971) and lindane (1952–1978). The continuous shifting from one compound to another was mainly attributed to the development of resistance of the cotton leaf worm (El-Sebae, Abou Zeid, & Saleh, 1993).

Persistent pesticides have serious environmental and health hazards. Based on the reports of their toxicity and adverse harmful effects to wildlife and humans, many organochlorine pesticides were banned or restricted from use or trade by the Ministry of Agriculture. Since 1980 DDT and lindane have been officially prohibited from agricultural use in Egypt, and in 1996 a Ministerial Decree prohibited the import and use of 80 pesticides including aldrin, dieldrin, endrin, chlordane, heptachlor, DDT, toxaphene, mirex, lindane, endosulfan, pentachlorophenol, heptachlor epoxide, as well as 20 other chlorine containing pesticides and organometallics. Nonetheless, many of the pesticides banned or withdrawn from developed markets are still produced and sold in developing country markets. These include DDT and other persistent organochlorine insecticides, which represent about 15% of the value of insecticide sales in regions outside USA, Western Europe, and Japan (Wood MacKenzie Consultants Ltd., 1994).

Although most of organochlorine pesticides are no in longer use, they are still being found as residues and they are occurring in food now as a result of environmental contamination. Pesticide residues in water, plants and grasses may be ingested by herbivores and eventually find their way into meat and milk (WHO, 1990).

The Arabian one-humped camel (*Camelus dromedarius*) constitutes an important source of meat in the semiarid and arid zones of Asia and Africa. The carcass characteristics of the camel are comparable to those of the other red meat animal species (Elgasim & Elhag, 1992). In Sharkia Province, Egypt, camel meat is very popular and frequently consumed along with the other red meats such as beef and mutton.

The aim of the present study is to investigate the extent of contamination with DDT compounds (DDTs), hexachlorocyclohexane isomers (HCHs), lindane (γ-HCH), aldrin, dieldrin, endrin, hexachlorobenzene (HCB), toxaphene, and chlordane compounds in camel, cattle and sheep carcasses slaughtered in Sharkia Province, Egypt, in order to ensure its safety for human consumption, as well as to study the effect of heat treatment of meat on the residual levels of such organochlorines.

2. Materials and methods

2.1. Sampling

A total of 270 samples (90 each of meat, liver, and kidney) were collected on the day of slaughtering from 90 carcasses (30 each of native breeds of camel, cattle and sheep) slaughtered in Sharkia Province, Egypt. The tissues were collected on 8 occasions over a period of 3 months (July–September, 2005) from different butcher shops. Each individual tissue sample (~700 g for meat, and ~300 g for liver and kidney) was separately packaged in a polyethylene bag and kept in cold ice during their transportation to the laboratory where they were kept at 4 °C until analysis. Samples were subjected to analysis within 24 h from their arrival. The mean fat content in the collected samples was calculated and the data is presented in Table 1. Samples were analyzed for the detection of DDTs, HCHs, lindane, dieldrin, aldrin, endrin, toxaphene, HCB and chlordane compounds.

2.2. Reagents

Petroleum ether, diethyl ether, *n*-hexane, acetonitrile, anhydrous sodium sulfate, and methylene chloride were purchased from Merck (Darmstadt, Germany). Florisil (PR Grade, 60–100 mesh) was purchased from Silica (Silica Co., USA). All solvents were of pesticide residue grade and subjected to a solvent purity test for residue analysis suitability. Florisil was activated at 130 °C for 24 h and cooled to room temperature.

2.3. Extraction of fat and residues

Each individual sample (50 g) was ground in a meat blender, at high speed, with anhydrous sodium sulfate (100 g) and petroleum ether (150, 100, and 100 ml, respectively) in three successive extraction steps for 2 min each, as described in the Pesticide Analytical Manual (http://vm.cfsan.fda.gov/~frf/pami3.html). Anhydrous sodium sulfate removes water and helps to disintegrate the sample. Samples were filtered with a vacuum pump after each extraction. The solvent was evaporated on a rotary evaporator at 40 °C till dryness.

2.4. Partitioning of the extract

Partitioning of the extracted samples was carried out according to the method of the Association of Official Analytical Chemists (AOAC International, 1999). At first,

Table 1
Fat content (%) in the organs from the different carcasses analyzed

Animal species	Age (year)	*N*	Meat (muscle)	Liver	Kidney
Camel	2–7	30	2.28 ± 0.17	3.21 ± 0.24	3.46 ± 0.38
Cattle	1.5–3.5	30	3.58 ± 0.62	4.31 ± 0.29	5.17 ± 0.58
Sheep	1–2.5	30	4.75 ± 0.77	3.62 ± 0.46	3.88 ± 0.27

500 ml *n*-hexane were partitioned with an equal volume of acetonitrile by mixing these two solvents in a separating funnel followed by separation of each solvent to be used for sample partitioning.

The extracted sample was transferred with a mixture of 80 ml *n*-hexane and 20 ml acetonitrile into a 100-ml separating funnel, followed by vigorous shaking for 2 min. After separation of two solvent layers, acetonitrile was collected in a flask after being passed through anhydrous sodium sulfate to remove any moisture. Another 20 ml acetonitrile was added to *n*-hexane and the aforementioned partitioning step was repeated 3 times. Finally, *n*-hexane was discarded while acetonitrile was evaporated on a rotary evaporator to a volume less than 10 ml to be used for Florisil cleanup.

2.5. Cleanup of the extract

Cleanup of the extracted samples, to remove the residual fat, was performed by transferring the extract into a glass chromatographic column (22 mm i.d.) containing 20 g activated Florisil (60–100 mesh) topped with 1-cm layer of anhydrous sodium sulfate. The prepared column was firstly rinsed with 50 ml petroleum ether, and then the extracted sample was transferred onto the column. The column was eluted with 200 ml eluent (10% anhydrous diethyl ether + 90% petroleum ether) followed by a second elution with 100 ml of another eluent (1% acetonitrile + 29% *n*-hexane + 70% methylene chloride). The collected eluant was concentrated on a rotary evaporator and dissolved in hexane to a volume of 10 ml. An aliquot of each extract was transferred to 2-ml injection vials to be ready for the analysis with the electron capture gas chromatography.

2.6. Determination of organochlorine pesticide residual concentrations

Organochlorine residues were determined by analysis of samples using electron capture gas chromatography (model 3600; Varian Medical Systems; Palo Alto, CA, USA) equipped with dual capillary columns (0.53 mm i.d. × 30 m; J&W Scientific, Folsom, CA, USA), electron capture detector, Varian 8100 auto-sampler, and Data station (DS-654). The extract was injected into a single inlet that was split into the dual columns. Instrumental settings were as follows: injector and detector temperatures were 230 °C and 300 °C, respectively; the gas chromatography oven temperature program was initiated at 150 °C for 5 min, raised to 170 °C (at a rate of 5 °C/min) and held for 10 min, then raised to 220 °C (at a rate of 10 °C/min) and held for 20 min (with a total run time of 44 min); the injection volume was 1 μl, and the flow rates of nitrogen make-up gas was 20 ml/min.

All organochlorine reference standards were obtained from Sigma–Aldrich (Germany). Calibration standard curves were created and the organochlorine pesticide residues were quantitatively determined by comparison with the standard solutions injected under the identical gas chromatography conditions.

The reliability of analytical methods was examined by fortifying the tested samples with known quantities of tested pesticides followed by the same procedure of extraction, cleanup and analysis. The percentage of recoveries of the organochlorines tested ranged from 86% to 109%. Residue levels for each pesticide were subsequently corrected for the recovery values.

2.7. Heat treatment of meat samples

The effect of heat treatment, using the normal kitchen processing procedure (boiling in water for 90 min), on the residual concentration for each of DDTs, lindane and dieldrin was determined in 36 positive selected samples (12 each of meat, liver and kidney) representing the three slaughtered species of camel, cattle and sheep. Moreover, the effect of heat treatment on the residual concentration of aldrin, endrin, toxaphene and HCB was checked in 20, 12, 8 and 6 positive selected samples, respectively.

2.8. Statistical analysis

All values are presented as means ± SE, and all measurements were carried out in triplicates. Data were subjected to one-way analysis of variance (ANOVA) to determine the differences in the organochlorine contents among the different species and different tissues analyzed. Significant differences among the means were determined by Tukey honestly significant difference (HSD) test. One-tailed *t*-test was conducted to identify the significance of the difference between the means of raw and cooked samples. All data analysis was performed using the VassarStats web site for statistical computation (http://faculty.vassar.edu/lowry/VassarStats.html).

3. Results and discussion

3.1. Organochlorine pesticide residues in camel, cattle and sheep carcasses

Public concern about the adverse environmental and human health impacts of organochlorine contaminants led to strict regulations on their use in developed nations more than two decades ago. Nonetheless, DDT and several other organochlorine pesticides are still being illegally used for agriculture and animal production programs in many developing countries and led to the contamination of food stuffs, especially those having a high fat content such as meat and meat products which contributed to the higher dietary intakes of most of the organochlorines (Kannan, Tanabe, Williams, & Tatsukawa, 1994). As a consequence, humans in this region are exposed to greater dietary levels of organochlorines of at least 5–100-fold greater than those in more developed nations (Kannan, Tanabe, Giesy, & Tatsukawa, 1997).

3.1.1. DDTs (dichloro-diphenyl-trichloroethane and its derivatives)

Out of the 90 carcasses analyzed, 13 (43.3%), 19 (63.3%), and 17 (56.7%) camel, cattle and sheep carcasses, respectively, were positive for DDTs, with an overall detection of 54.4% (49/90) among the analyzed carcasses of the three animal species.

The frequency of detection of DDT in meat is higher in the developing countries than in more developed ones. DDT was detected in 100% and 90% of bovine and lamb meat, respectively, in Iraq (Al-Omar, Al-Bassomy, Al-Ogaily, & Al-Din Shebl, 1985). It was also detected in a higher incidence of 96% of bovine meat and organs in Nigeria (Osibanjo & Adeyeye, 1997), and in 88% of meat and meat products in Spain (Herrera et al., 1996). In Canada, however, DDT was only detected in 21% of analyzed fat samples of different slaughtered animals (Frank, Braun, Stonefield, Rasper, & Luyken, 1990). The higher detection frequencies in DDT in developing countries may be resulted from the illegal use of such compound in agriculture purposes.

The mean values of the residual concentrations (ng/g wet weight) of DDTs in the examined muscle of camel, cattle, and sheep in the present study, were 13.9, 17.9, and 20.3, respectively. The corresponding levels in liver samples were 34.6, 57.2, and 49.6, respectively, while the equivalent DDTs levels in the analyzed kidneys were 25.4, 36.3, and 25.3, respectively (Fig. 1). The overall mean of DDTs in muscle, liver and kidney of the three species were 17.4, 47.1, and 28.9, respectively. In general, the order of magnitude for DDTs level in the examined liver samples was about 3 times that of the muscle and 2 times that of the kidney; nonetheless it was approximately 100× below the maximal permitted concentration (5 μg/g) set by Egypt for DDT in meat (EOS, 1992a).

Levels of DDT in analyzed meat samples of the present study are comparable with those reported in meat from Vietnam (Kannan, Tanabe, Quynh, Hue, & Tatsukawa, 1992a) and Spain (Herrera et al., 1996). Lower levels, however, were detected in meat in Sweden (Glynn et al., 2000) and Taiwan (Doong, Lee, & Sun, 1999). On the other hand, much higher DDT concentration had been detected in meat analyzed in Thailand (Tanabe et al., 1991), India (Kannan, Tanabe, Ramesh, Subramanian, & Tatsukawa, 1992b), Nigeria (Osibanjo & Adeyeye, 1997), and Belarus (Barkatina et al., 1999).

3.1.2. HCHs (hexachlorocyclohexane isomers)

HCHs isomers (α, β, γ and δ isomers) were detected in 11 (36.7%), 20 (66.7%), and 15 (50%) of camel, cattle and sheep carcasses, respectively; with an overall detection of 51.1% (46/90). Higher contamination incidence of 75% was detected for food from Taiwan by Doong et al. (1999). In the present study, the mean values of HCHs (ng/g wet weight) in the examined muscle, liver and kidney of camel were 2.4, 25.5 and 21.7, respectively; while the corresponding values for cattle were 4.58, 46.1 and 33.3, respectively; and for sheep they were 3.72, 35.2, and 18.6, respectively (Fig. 2). These results are comparable with data reported for HCHs in meat from Vietnam (Kannan et al., 1992a), however higher levels of HCHs contamination was reported in meat from India (Kannan et al., 1992b; Singh & Chawla, 1988).

3.1.3. Lindane (gamma-hexachlorocyclohexane, γ-HCH)

Lindane is the name given to 99% pure γ-hexachlorocyclohexane (γ-HCH). Our results indicated that 11 (36.7%), 18 (60.0%), and 14 (46.7%) camel, cattle and sheep car-

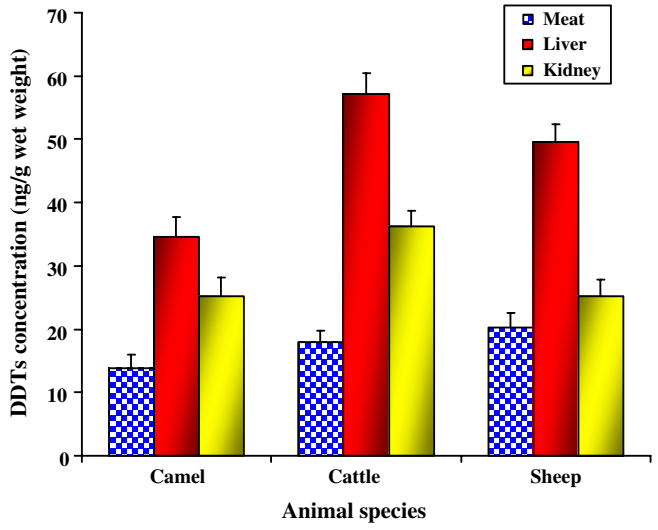

Fig. 1. DDTs concentrations (ng/g wet weight) in camel, cattle and sheep carcasses slaughtered in Sharkia Province, Egypt. $N = 90$ for each of the tissue analyzed. Values represent the mean ± SE. DDTs = *o,p*'-DDT + *p,p*'-DDD + *p,p*'-DDE + *p,p*'-DDT.

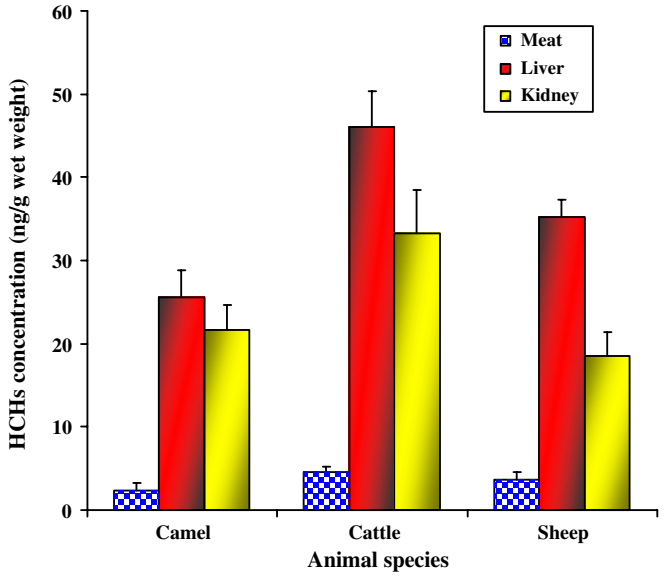

Fig. 2. HCHs concentrations (ng/g wet weight) in camel, cattle and sheep carcasses slaughtered in Sharkia Province, Egypt. $N = 90$ for each of the tissue analyzed. Values represent the mean ± SE. HCHs = α + β + γ + δ isomers.

casses, respectively, were positive for lindane, with an overall mean detection of 47.8% (43/90) among the analyzed carcasses of the three animal species. Previous studies showed that lindane has been detected in 100% of analyzed lamb and pork meat and meat products in Spain (Herrera et al., 1994). It has been also detected in 90% of analyzed meat and organs of cattle in Nigeria (Osibanjo & Adeyeye, 1997); however, it was only detected in <10% of analyzed animal fat samples in Canada (Frank et al., 1990).

The mean levels of lindane (ng/g wet weight) in the analyzed muscle, liver and kidneys were 0.33, 3.26, and 1.83, respectively, for camel carcasses; 0.72, 6.06, and 5.26, respectively, for cattle carcasses and 0.45, 5.16, and 2.58, respectively, for sheep carcasses (Fig. 3). It is evident that the order of magnitude for lindane level in the examined liver samples was about 8–11 times that of the muscle; nonetheless its concentration in liver samples was still 165× below the maximal permitted concentration (1 μg/g) set by Egypt for lindane in meat (EOS, 1991a). In this context, Garcia-Regueiro, Diaz, and Monfort (1987) declared that lindane level in porcine livers was about 43 times more than that in the meat (510 versus 11.8 ng/g).

Lindane level in the meat samples of the present study is in agreement with those reported in meats from Vietnam (Kannan et al., 1992a), India (Kannan et al., 1992b) and Solomon Islands (Kannan et al., 1994), although a much higher level of lindane has been reported in meat from Belarus (2000 ng/g; Barkatina et al., 1999). On the other hand, a lower lindane level (0.09 ng/g) was detected in Meat and fat from Australia (Kannan et al., 1994).

3.1.4. Dieldrin

Dieldrin was determined in 12 (40.0%), 15 (50.0%), and 13 (43.3%) of the examined camel, cattle and sheep carcasses, respectively, with an overall mean detection of 44.4% (40/90) among the three analyzed animal species. Much higher detection incidence of 100% has been detected by Osibanjo and Adeyeye (1997) in muscle and organs of cattle and goat slaughtered in Nigeria. In contrast, lower detection incidence (<10%) for dieldrin has been detected in fat samples from different slaughter animals in Canada (Frank et al., 1990), and also in meat and meat products from Spain (Herrera et al., 1996).

The present study showed that the mean levels of dieldrin (ng/g wet weight) in the analyzed muscle, liver and kidneys were 0.15, 3.07, and 2.09, respectively, for camel carcasses; 0.62, 6.19, and 4.17, respectively, for cattle carcasses and 0.52, 3.91, and 2.65, respectively, for sheep carcasses (Fig. 4). Liver samples contained dieldrin of about 7–20-folds higher than its corresponding levels in muscle, nonetheless it was 30–65 times lower than that of the recommended maximal limit of 200 ng/g for dieldrin in Egypt (EOS, 1992b). Dieldrin levels in this study are comparable with those detected in meat and meat products from Vietnam (Kannan et al., 1992a), Spain (Herrera et al., 1996), Australia (Kannan et al., 1994), and Taiwan (Doong et al., 1999). However, much higher concentration of >70 ng/g, had been reported in pork meat from Thailand (Tanabe et al., 1991) and also in cattle and goat muscle from Nigeria (Osibanjo & Adeyeye, 1997).

3.1.5. Aldrin

Aldrin could not be detected in any of the analyzed muscle samples (except in 4 samples out of the 30 sheep carcasses), while it was detected in both liver and kidney samples from 10 (33.3%) and 13 (43.3%) cattle and sheep carcasses, respectively. In camel carcasses, although all of the analyzed kidneys were negative for aldrin, seven liver samples (23.3%) were contaminated with aldrin.

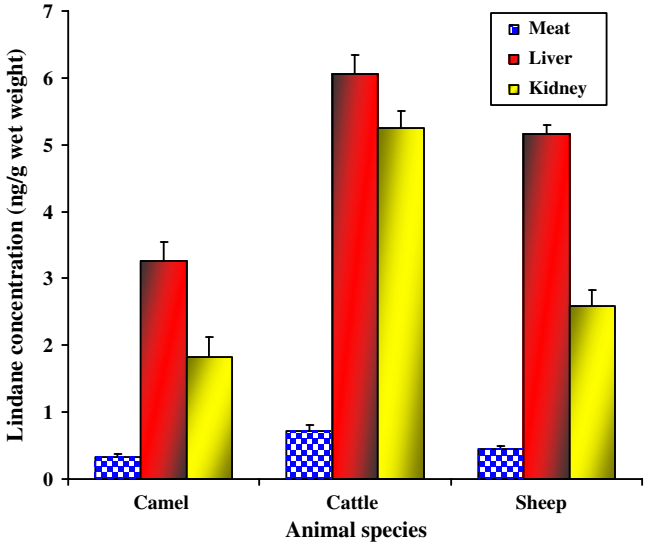

Fig. 3. Lindane concentrations (ng/g wet weight) in camel, cattle and sheep carcasses slaughtered in Sharkia Province, Egypt. $N = 90$ for each of the tissue analyzed. Values represent the mean ± SE.

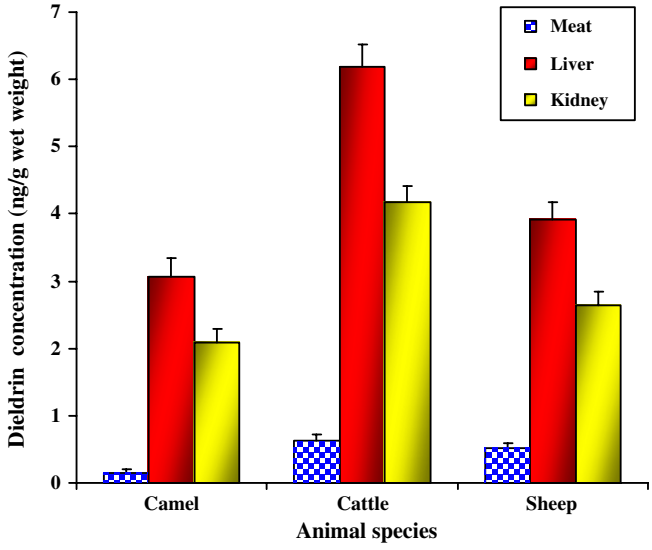

Fig. 4. Dieldrin concentrations (ng/g wet weight) in camel, cattle and sheep carcasses slaughtered in Sharkia Province, Egypt. $N = 90$ for each of the tissue analyzed. Values represent the mean ± SE.

Although aldrin was detected in 66% of bovine meat and organ samples from Nigeria (Osibanjo & Adeyeye, 1997), it was only determined in 2% of the tested food samples from Taiwan (Doong et al., 1999) and it could not be detected in the ruminant fat samples in Poland (Falandysz & Kannan, 1992).

The residual concentrations of aldrin in positive liver samples from camel, cattle and sheep were 0.59, 2.46 and 1.79 ng/g wet weight, respectively (Fig. 5) The corresponding concentrations in kidney samples from cattle and sheep were 1.75 and 1.39 ng/g wet weight, respectively. The four-positive sheep muscles exhibited a lower mean for aldrin concentration of 0.198 ng/g wet weight. Aldrin levels in the samples analyzed are much lower than the recommended maximal limit of 200 ng/g set for aldrin in Egypt (EOS, 1992b). The concentration of aldrin in the meat samples of the present study is approximately similar to that reported in meat from Vietnam (Kannan et al., 1992a); nonetheless much higher concentrations had been detected in meat and meat products from Italy (6.7–8.3 ng/g; Cantoni & Blazaretti, 1993) and also in meat from Nigeria (10 ng/g; Osibanjo & Adeyeye, 1997).

3.1.6. Endrin

Endrin was detected in both liver and kidney samples from 3 (10.0%), 6 (20.0%), and 5 (16.7%) of the analyzed camel, cattle and sheep carcasses, respectively. Nonetheless, it could not be detected in any of the analyzed muscles from the three species examined. Similar findings has been reported in Spain by Herrera et al. (1994) who could not detect endrin in any of the analyzed beef and lamb meat.

The residual concentrations of endrin in positive liver samples from camel, cattle and sheep were 1.17, 1.87 and 1.24 ng/g wet weight, respectively. The corresponding concentrations in kidney samples were 0.47, 0.68 and 0.83 ng/g wet weight, respectively (Fig. 6). Our findings for endrin, however, are much lower than the maximal permissible limits of 100 ng/g set by the EOS (1991b).

3.1.7. Toxaphene, HCB, and chlordane

Toxaphene, HCB and chlordane had been rarely reported in food from Egypt. Out of the 90 carcasses examined in the present study, only 7 (7.8%; 3 cattle + 4 sheep), 8 (8.9%; 5 cattle + 3 sheep) and 3 (3.3%; 2 cattle + 1 sheep) carcasses were contaminated with toxaphene, HCB and chlordane compounds, respectively. On the other hand, these three contaminants could not be detected in any of the analyzed samples from camel.

Toxaphene was determined at mean levels of 0.14, 0.30 and 0.22 ng/g in muscle, liver and kidney samples, respectively, from cattle carcasses, while the corresponding levels in sheep carcasses were 0.12, 0.36 and 0.20 ng/g wet weight, respectively. A maximum toxaphene level of 9.7 ng/g wet weight has been detected in bivalve samples from the Mediterranean coast at Demiatta city, Egypt (Abd-Allah, Ali, & El-Sebae, 1998).

Both HCB and chlordane could not be detected in any of the analyzed muscle samples from the three animal species. HCB, however, could be detected in the liver and kidney of cattle at low concentrations of 0.11 and 0.15 ng/g, respectively. The corresponding values for HCB in the sheep liver and kidney were 0.13 and 0.12 ng/g, respectively. HCB value of the present study is comparable with those reported for meat from Thailand (Tanabe et al., 1991) and Vietnam (Kannan et al., 1992a), while higher HCB level was reported for meat from India (Kannan et al., 1992b).

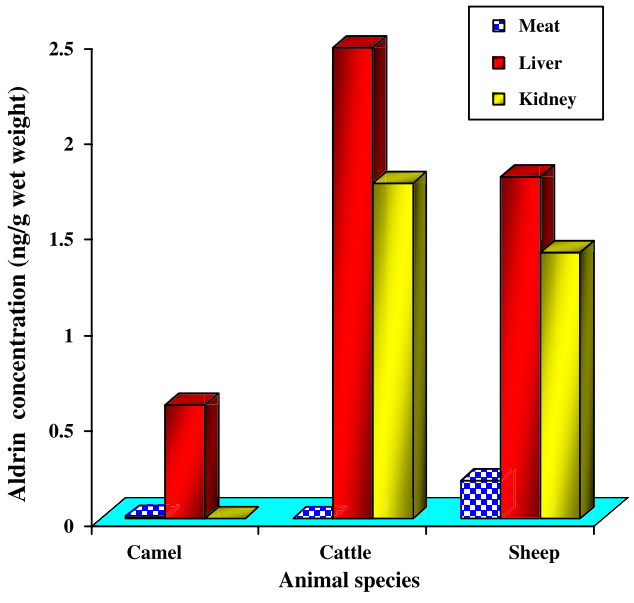

Fig. 5. Aldrin concentrations (ng/g wet weight) in camel, cattle and sheep carcasses slaughtered in Sharkia Province, Egypt. $N = 90$ for each of the tissue analyzed. Values represent the mean ± SE.

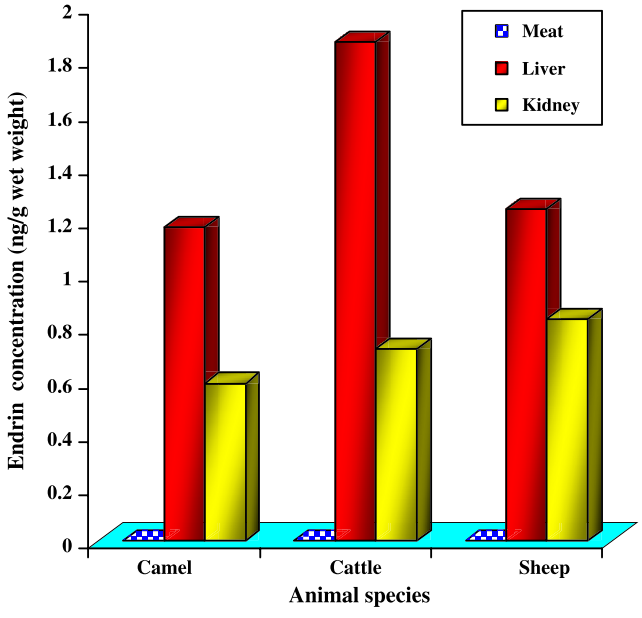

Fig. 6. Endrin concentrations (ng/g wet weight) in camel, cattle and sheep carcasses slaughtered in Sharkia Province, Egypt. $N = 90$ for each of the tissue analyzed. Values represent the mean ± SE.

Chlordane was detected at low concentration of 0.1 and 0.07 ng/g wet weight in liver and kidney samples from cattle, respectively; while its level in the liver and kidney of the sole positive sheep carcass were 0.08 and 0.1 ng/g, respectively. Higher average of chlordane concentration (3.1 ng/g wet weight) has been reported in meat and fat from Australia (Kannan et al., 1994). Data for chlordane contamination in meat animals from Egypt are lacking; nonetheless studies on chlordane contamination in fish from Egypt revealed average concentration of 0.1–2.7 ng/g wet weight (Abou-Arab, Gomaa, Badawy, & Naguib, 1995; Yamashita, Urushigawa, Masunaga, Walash, & Miyazaki, 2000).

In general, the concentration of organochlorines observed for the Egyptian meat in this study were comparable with those reported in meat examined in Vietnam, while they were lower than those reported in meat from India.

3.2. Incidence of contamination with the different organochlorines

Among various organochlorines examined in the present study, DDTs and HCHs are the most prominently noticed compounds, as they were detected at a high incidence of >50%. On the other hand, toxaphene, HCB and chlordane compounds were detected at a low incidence and they were only present in less than 10% of the analyzed samples. Generally, the incidence of contamination of the examined samples by the organochlorines followed the order of DDTs > HCHs > lindane > dieldrin > aldrin > endrin > HCB > toxaphene > chlordane (Fig. 7). Likewise, approximately similar order for organochlorine contamination has been reported by Falandysz and Kannan (1992) in the slaughtered animals in Poland.

3.3. Variations in organochlorine among the different species

Amongst the three species examined (camel, cattle and sheep) in the present study, the incidence of contamination as well as the residual concentrations of all the pesticides detected in camel carcasses were lower than those detected for cattle and sheep. The reason for such a divergence could be that most of camels in Egypt are raised in desert regions, in which the use of organochlorines is limited, while cattle are raised in the rural area in which organochlorines are frequently used. Furthermore, the fat content, which is the main site for organochlorine accumulation, in the muscle and organs of camel is lower than that determined in cattle and sheep (Table 1). Our findings substantiate what had been reported by Hashemy-Tonkabony et al. (1981) who determined the chlorinated pesticides in meat animals (cattle, sheep, goat and camel) from Iran and concluded that the incidence and the concentration of the most pesticides detected were lowest in the camel and highest in sheep.

3.4. Variations in organochlorine concentrations among the different organs in the same animal species

Among various organs analyzed from the three species, liver samples were generally showed the highest organochlorine concentration followed by the kidneys, while muscle samples exhibited the lowest residual concentrations (Fig. 8).

The analysis of variance (ANOVA) test was conducted to compare the differences in organochlorine levels amongst the analyzed organs within the same animal species. All of the determined organochlorines showed high significant differences ($P < 0.001$) in their concentrations among the three analyzed organs within the same species.

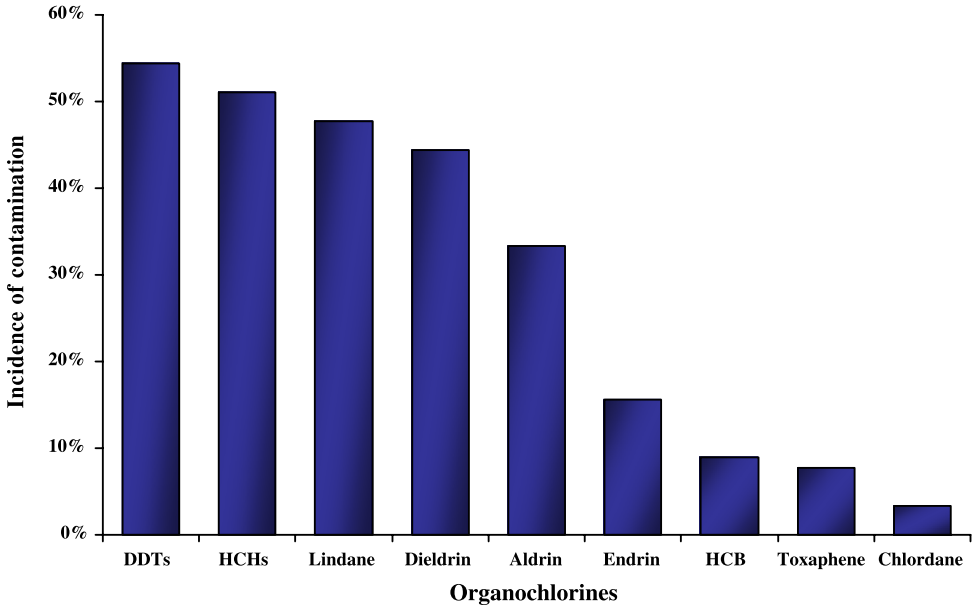

Fig. 7. Incidence of contamination of examined camel, cattle and sheep carcasses ($N = 90$) with the different organochlorines analyzed.

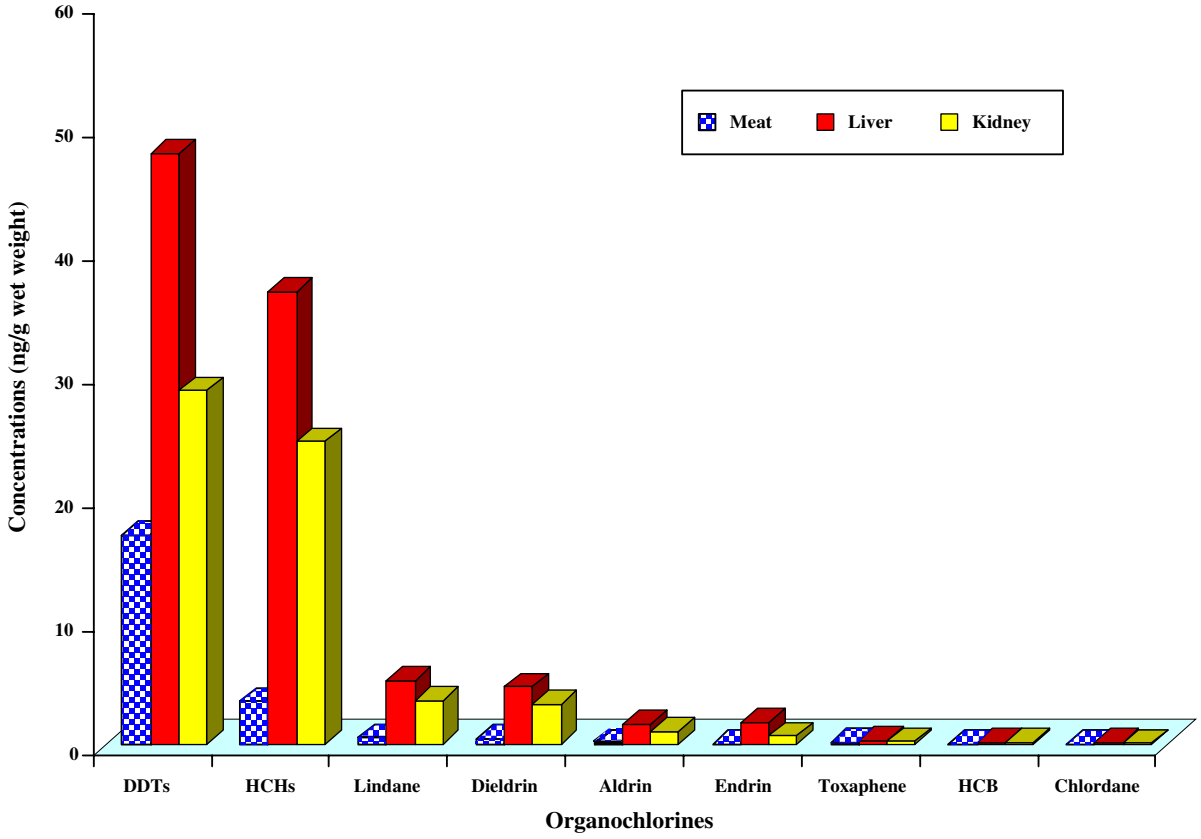

Fig. 8. Concentration of the different organochlorines in the different organs analyzed. Pooled data from all of the examined camel, cattle and sheep carcasses ($N = 90$).

In camel carcasses, Tukey HSD test indicated a significant difference ($P < 0.01$) in the mean levels of DDTs, HCHs, dieldrin and endrin between each of the three organs analyzed. Tukey HSD also exhibited a significant difference ($P < 0.01$) in the muscle levels of lindane in comparison with their corresponding levels in livers or kidneys; however, no significant difference is found in its level between liver and kidney samples. For aldrin, the liver samples showed significant difference ($P < 0.01$) in comparison with its corresponding levels in the muscles or the kidneys, while no difference is found for aldrin between the muscle and kidney samples.

In cattle carcasses, Tukey HSD test indicated significant differences ($P < 0.01$) in the mean values of DDTs, HCHs, dieldrin, aldrin, endrin, toxaphene and HCB between each of the three organs analyzed. Additionally, the Tukey HSD test declared a significant difference ($P < 0.01$) between lindane level in muscle in comparison with its level in liver or kidney samples, while no significant difference ($P > 0.05$) is detected for lindane level between the liver and the kidneys.

In sheep samples, Tukey HSD test declared significant difference in DDTs level between liver and each of muscle and kidney samples; but not between its level in muscle and that in kidney. Lindane, dieldrin, toxaphene and HCB, however, exhibited significant differences ($P < 0.01$) in their mean levels among each of the three organs analyzed. Muscle levels of aldrin and endrin exhibited significant differences ($P < 0.01$) in comparison with their corresponding levels in each of the liver and kidney samples, although their values exhibited non significant difference between the liver and kidney samples.

3.5. Variations in organochlorine concentrations within the same organ from the different animal species

The variations in the organochlorine concentrations within the same tissue amongst the three different animal species is estimated by conducting the ANOVA test; while the absolute difference between any two sample means was identified by the Tukey HSD test which indicating various degrees of significant differences according to the various organochlorines and the tissues analyzed.

No difference ($P > 0.05$) was detected in DDTs values between muscle of cattle and those of sheep or camel, although significant ($P < 0.01$) lower DDTs level was determined in camel muscles in comparison with its level in sheep muscles. In liver samples, however, DDTs exhibited lower significant level for camel in comparison with its corresponding levels in cattle ($P < 0.01$) and sheep ($P < 0.05$); nonetheless no difference was detected for DDTs level between cattle and sheep livers. In kidney samples, a significant higher ($P < 0.01$) DDTs level was determined for cattle in comparison with camel and sheep kidneys, but no difference is detected between camel and sheep kidneys.

Significant ($P < 0.01$) lower levels in HCHs, lindane and dieldrin were observed in camel muscle in comparison with their levels in cattle and sheep muscles, while no significant difference is observed in their levels between muscles of cattle and sheep. HCHs and lindane levels in camel liver were significantly lower ($P < 0.01$) than their corresponding levels in cattle and sheep. Significant differences ($P < 0.01$) were observed in HCHs level between cattle and sheep liver, while no difference was observed for lindane between cattle and sheep livers. Higher levels ($P < 0.01$) of HCHs and lindane were detected in cattle kidney in comparison with their levels in camel and sheep kidneys, while no difference ($P > 0.05$) has been observed for HCHs and lindane between camel and sheep kidneys.

Camel muscle exhibited significant lower levels ($P < 0.01$) of dieldrin compared with its levels in cattle and sheep muscles. Significant higher dieldrin levels ($P < 0.01$) were detected in cattle liver and kidney in comparison with its levels in the corresponding organs of camel and sheep, while no difference was detected for dieldrin levels in liver or kidney samples between camel and sheep.

A significant ($P < 0.01$) lower level of aldrin had been detected in camel liver in comparison with cattle and sheep livers. Also, a significant lower aldrin value ($P < 0.05$) was detected in sheep liver compared with cattle liver.

A significant higher endrin level was detected in cattle liver compared with its level in camel or sheep livers, while no difference has been detected for endrin amongst the kidneys from the three animal species. Additionally, no differences ($P > 0.05$) had been detected in the toxaphene, HCB and chlordane levels between cattle and sheep organs.

3.6. 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 often less toxic, which renders safer products for human consumption (Abou-Arab, 2002; Garcar, Hrusovsky, & Smirjak, 1987; Zabik et al., 1995).

In the present study, selected muscle, 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 indicated significant reduction ($P < 0.01$) in all of the organochlorine tested below the raw control samples after heat treatment. The higher

Table 2
Effect of heat treatment (boiling for 90 min) on the residual contents of organochlorines in tissue samples from various slaughtered carcasses

Pesticides	Tissue samples	*N*	Mean ± SE (ng/g)		Reduction (%)
			Before cooking	After cooking	
DDTs	Muscle	12	17.63 ± 1.93	10.24 ± 1.34	41.9
	Liver	12	49.24 ± 3.07	30.25 ± 2.15	38.6
	Kidney	12	29.32 ± 2.12	16.82 ± 1.35	42.6
	Total	36	96.19 ± 7.12	57.31 ± 4.84	40.4
Lindane	Muscle	12	0.58 ± 0.03	0.27 ± 0.02	53.4
	Liver	12	5.13 ± 0.27	2.47 ± 0.018	51.9
	Kidney	12	4.57 ± 0.19	1.89 ± 0.015	58.6
	Total	36	10.28 ± 0.29	4.63 ± 0.053	55.0
Dieldrin	Muscle	12	0.42 ± 0.04	0.29 ± 0.03	31.0
	Liver	12	5.02 ± 0.19	3.40 ± 0.11	32.3
	Kidney	12	3.41 ± 0.13	2.29 ± 0.09	32.9
	Total	36	8.85 ± 0.36	5.98 ± 0.23	32.4
Aldrin	Muscle	6	0.18 ± 0.02	0.12 ± 0.01	33.4
	Liver	8	1.62 ± 0.14	1.07 ± 0.09	34.0
	Kidney	6	1.54 ± 0.11	1.03 ± 0.07	33.1
	Total	20	3.34 ± 0.27	2.22 ± 0.17	33.5
Endrin	Muscle	0	–	–	–
	Liver	8	1.43 ± 0.09	1.01 ± 0.07	29.4
	Kidney	4	0.69 ± 0.05	0.49 ± 0.03	29.0
	Total	12	2.12 ± 0.14	1.50 ± 0.10	29.2
Toxaphene	Muscle	2	0.13 ± 0.03	0.07 ± 0.01	46.2
	Liver	3	0.32 ± 0.05	0.18 ± 0.04	43.7
	Kidney	3	0.21 ± 0.03	0.13 ± 0.03	38.1
	Total	8	0.66 ± 0.11	0.38 ± 0.08	42.7
HCB	Muscle	–	–	–	–
	Liver	3	0.11 ± 0.01	0.07 ± 0.01	36.4
	Kidney	3	0.15 ± 0.03	0.09 ± 0.02	40.0
	Total	6	0.26 ± 0.04	1.50 ± 0.03	38.2

reduction percentage was recorded for lindane (55%) followed by toxaphene (42.7%) and DDTs (40.4%), while relatively lower reduction rates of 32.4%, 33.5% and 29.2% were calculated for dieldrin, aldrin and endrin, respectively (Table 2).

The effect of heat treatment on the residual concentration of organochlorine pesticides has been previously studied in various meat and meat products. A reduction rate of 44% has been detected for DDT after thermal processing of lamb meat cuts (Bayarri, Conchello, Arino, Lazaro, & Herrera, 1994). A reduction rate of 60% in lindane contents has been reported for cooked beef meat after heating at 115 °C for 2 h (Jan & Malnersic, 1982). Also, a high reduction rate of 65% in lindane contents has been reported in rabbit meat after boiling for 1.5 h (Mirna & Coretti, 1979), nonetheless lower reduction rates (17–35%) in lindane contents has been estimated by Conchello, Herrera, Arino, Lazaro, and Bayarri (1993) for ovine meat after several kitchen processing including grilling roasting and cooking. Additionally, significant reductions in DDT complex, dieldrin, toxaphene and HCB contents in fish fillets had been reported after heat treatment (Zabik et al., 1995).

The significant loss in the organochlorine pesticide residues in meat and organs during cooking could be attributed to the volatility of these compounds and to the elimination with the fat rendering induced by high temperatures.

4. Conclusion

It can be concluded that organochlorine pesticide residues were detected at very low levels in the examined muscle and organs of camel, cattle and sheep carcasses slaughtered in Sharkia Province and such levels are much less than the permissible limits. Moreover, the efficient cooking could significantly reduce the residual concentration of the organochlorine in meats, therefore consumption of camel, bovine and ovine meat in Sharkia Province does not constitute a threat to public health.

References

Abd-Allah, A. M., Ali, H. A., & El-Sebae, A. (1998). Level of chlorinated hydrocarbons in a teleost fish and a bivalve from the Egyptian Mediterranean Coast and Nile Estuary. *Zeitschrift Fur Lebensmittel-Untersuchung Und-Forschung A -Food Research and Technology, 206*, 25–28.

Abou-Arab, A. A. (2002). Degradation of organochlorine pesticides by meat starter in liquid media and fermented sausage. *Food and Chemical Toxicology, 40*, 33–41.

Abou-Arab, A. A., Gomaa, M. N., Badawy, A., & Naguib, Kh. (1995). Distribution of organochlorine pesticides in the Egyptian aquatic ecosystem. *Food Chemistry, 54*, 141–146.

Al-Omar, M., Al-Bassomy, M., Al-Ogaily, N., & Al-Din Shebl, D. (1985). Residue levels of organochlorine insecticides in lamb and beef from Baghdad. *Bulletin of Environmental Contamination and Toxicology, 34*, 509–512.

AOAC International (1999). In P. Cunnif (Ed.), *Official methods of analysis of AOAC international* (16th ed.). Gaithersburg, MD, USA: AOAC International.

Barkatina, E. N., Pertsovsky, A. L., Murokh, V. I., Kolomiets, N. D., Shulyakovskaya, O. V., Venger, O. N., et al. (1999). Organochlorine pesticide residues in basic food products and diets in the Republic of Belarus. *Bulletin of Environmental Contamination and Toxicology, 63*, 235–242.

Bayarri, S., Conchello, P., Arino, A., Lazaro, R., & Herrera, A. (1994). DDT, DDT metabolites, and other organochlorines as affected by thermal processing in three commercial cuts of lamb. *Bulletin of Environmental Contamination and Toxicology, 52*, 554–559.

Cantoni, C., & Blazaretti, C. (1993). Organochlorine pesticides and heavy metals in foods of animal origin. *Industrie Alimentari, 32*, 377–382.

Conchello, M. P., Herrera, A., Arino, A., Lazaro, R., & Bayarri, S. (1993). Effect of several kitchen treatments on hexachlorocyclohexane residues in ovine meat. *Bulletin of Environmental Contamination and Toxicology, 51*, 612–618.

Doong, R. A., Lee, C. Y., & Sun, Y. C. (1999). Dietary intake and residues of organochlorine pesticides in foods from Hsinchu, Taiwan. *Journal of AOAC International, 82*, 677–682.

Elgasim, E. A., & Elhag, G. A. (1992). Carcass characteristics of the Arabian camel. *Camel News Letter, 9*, 20–24.

El-Sebae, A. H., Abou Zeid, M., & Saleh, M. A. (1993). Status and environmental impact of Toxaphene in the third world – a case study of African agriculture. *Chemosphere, 27*, 2063–2072.

EOS (1991a). Maximum limits for pesticide residues in meat. Paper No. 1966. Lindane. Egyptian Organization for Standardization and Quality Control, Cairo, Egypt.

EOS (1991b). Maximum limits for pesticide residues in meat. Paper No. 1954. Endrin. Egyptian Organization for Standardization and Quality Control, Cairo, Egypt.

EOS (1992a). Maximum limits for pesticide residues in meat. Paper No. 2081. DDT. Egyptian Organization for Standardization and Quality Control, Cairo, Egypt.

EOS (1992b). Maximum limits for pesticide residues in meat. Paper No. 2078. Aldrin and dieldrin. Egyptian Organization for Standardization and Quality Control, Cairo, Egypt.

Falandysz, J., & Kannan, K. (1992). Organochlorine pesticide and polychlorinated biphenyl residues in slaughtered and game animal fats from the northern part of Poland. *Zeitschrift fuer Lebensmittel-Untersuchung und-Forschung, 195*, 17–21.

Frank, R., Braun, H. E., Stonefield, K. I., Rasper, J., & Luyken, H. (1990). Organochlorine and organophosphorus residues in the fat of domestic farm animal species, Ontario, Canada 1986–1988. *Food Additives and Contaminants, 7*, 629–636.

Garcar, J., Hrusovsky, J., & Smirjak, M. (1987). The effect of processing on the contents of organochlorine pesticide residues in canned meat. *Veterinarni Medicina (Praha), 32*, 619–626.

Garcia-Regueiro, J. A., Diaz, I., & Monfort, J. M. (1987). Determination of organochlorine pesticides by capillary column gas chromatography (CGC) in meat and meat products from markets in Gerona (Spain). *Revista de Agroquimica y Tecnologia de Alimentos, 27*, 405–417.

Glynn, A. W., Wernroth, L., Atuma, S., Linder, C.-E., Aune, M., Nilsson, I., et al. (2000). PCB and chlorinated pesticide concentrations in swine and bovine adipose tissue in Sweden 1991–1997: Spatial and temporal trends. *Science of the Total Environment, 246*, 195–206.

Hashemy-Tonkabony, S. E., Afshar, A., Ghazi-Saidi, K., Assadi-Langaroodi, F., Messchi, M., & Ahmadi, Z. (1981). Chlorinated pesticide residues in meat and fat from animal raised in Iran. *Journal of the American Oil Chemists' Society, 58*, 89–91.

Herrera, A., Arino, A., Conchello, P., Lazaro, R., Bayarri, S., Perez-Arquillue, C., et al. (1996). Estimates of mean daily intakes of persistent organochlorine pesticides from Spanish fatty foodstuffs. *Bulletin of Environmental Contamination and Toxicology, 56*, 173–177.

Herrera, A., Arino, A., Conchello, M. P., Lazaro, R., Bayarri, S., & Perez, C. (1994). Organochlorine pesticide residues in Spanish meat products and meat of different species. *Journal of Food Protection, 57*, 441–444.

Jan, J., & Malnersic, S. (1982). Effects of some food additives and fat content in meat on lindane transformation to nonpolar compounds

during cooking. *Journal of Agricultural and Food Chemistry, 30*, 1253–1256.

Kannan, K., Tanabe, S., Giesy, J. P., & Tatsukawa, R. (1997). Organochlorine pesticides and polychlorinated biphenyls in foodstuffs from Asian and oceanic countries. *Reviews of Environmental Contamination and Toxicology, 152*, 1–55.

Kannan, K., Tanabe, S., Quynh, H. T., Hue, N. D., & Tatsukawa, R. (1992a). Residue pattern and dietary intake of persistent organochlorine compounds in foodstuffs from Vietnam. *Archives of Environmental Contamination and Toxicology, 22*, 367–374.

Kannan, K., Tanabe, S., Ramesh, A., Subramanian, A., & Tatsukawa, R. (1992b). Persistent organochlorine residues in foodstuffs from India and their implications on human dietary exposure. *Journal of Agricultural and Food Chemistry, 40*, 518–524.

Kannan, K., Tanabe, S., Williams, R. J., & Tatsukawa, R. (1994). Persistent organochlorine residues in foodstuffs from Australia, Papua New Guinea and the Solomon Islands: Contamination levels and human dietary exposure. *Science of the Total Environment, 153*, 29–49.

Mansour, S. A. (2004). Pesticide exposure – Egyptian scene. *Toxicology, 198*, 91–115.

Mirna, A., & Coretti, K. (1979). Influence of processing on the degradation of pesticides in meat products. *Meat Science, 3*, 97–107.

Osibanjo, O., & Adeyeye, A. (1997). Organochlorine pesticide residues in foodstuffs of animal origin in Nigeria. *Bulletin of Environmental Contamination and Toxicology, 58*, 206–212.

Singh, P. P., & Chawla, R. P. (1988). Comparison of sulphuric acid treatment and column chromatographic clean-up procedures for the gas chromatographic determination of organochlorine compounds in some food commodities. *Journal of Chromatography, 457*, 387–392.

Tanabe, S., Kannan, K., Tabucanon, M. S., Siriwong, C., Ambe, Y., & Tatsukawa, R. (1991). Organochlorine pesticide and polychlorinated biphenyl residues in foodstuffs from Bangkok, Thailand. *Environmental Pollution, 72*, 191–203.

WHO (1990). *Public health impact of pesticides used in agriculture. WHO in collaboration with the UNEP*. Geneva: World Health Organization.

Wood MacKenzie Consultants Ltd., Agrichemical Division (1994). Update of the Country Report. Reference Volume of the Agrichemical Service, Edinburgh, Scotland, December 1994.

Yamashita, N., Urushigawa, Y., Masunaga, S., Walash, M., & Miyazaki, A. (2000). Organochlorine pesticides in water, sediment and fish from the Nile River and Manzala Lake in Egypt. *International Journal of Environment and anal Chemistry, 77*, 289–303.

Zabik, M. E., Zabik, M. J., Booren, Al M., Nettles, M., Song, J.-H., Welch, R., et al. (1995). Pesticides and total polychlorinated biphenyls in Chinook salmon and carp harvested from the Great Lakes: Effects of skin-on and skin-off processing and selected cooking methods. *Journal of Agricultural and Food Chemistry, 43*, 993–1001.