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Toxic Substance in Various Food Products in Saudi Arabia: A Review of Evidenced

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This review aim to search and summarize available evidence of Heavy metals, Polycyclic Aromatic Hydrocarbons (PAHs) and Organochlorine pesticides (OCPs) in various food products in the Kingdom of Saudi Arabia (KSA). Different electronic databases were searched (Web of Science, Google Scholar, Pub Med and Science Direct) with keywords. Included studies show evidence of toxic substance in food products from different location in KSA. The included studies was consulted and seen by a specialist. A total of eight studies determined evidence of presence of toxic substance in various food products in KSA.Three studies determined concentration of Mercury, Cadmium, and Lead. Two studies examined levels of PAHs in vegetables and fish and also three studies measure levels of OCPs in chicken and vegetables from different cities in KSA. Overall, leafy vegetables contained the highest levels of heavy metals and OCPs whilepotato was biggest source of PAHs exposure followed by eggplant and carrot. Even though few studies met the inclusion criteria for this review, evidence of toxic substance in various products in KSA are showed in this review study. Araise concern for monitoring and further studies of toxic substance in food products are needed.

Key words: Toxic substance, OCPs, PAHs, Heavy metals, Saudi Arabia

Exposure of toxic contaminants is one of the risk factors of chronic disease such as heart disease, stroke, cancer, chronic respiratory diseases and diabetes. According to World Health Organization these diseases are leading cause of mortality in the world, representing 63% of all deaths[1]. The incidence of chronic disease in Saudi Arabia has increased substantially in the last decade. The World Health Organization (WHO) reported that in 2002, 69% of all deaths in the Kingdom are accounted in chronic diseases[2].

Several studies shown that this diseases are not merely cause by genetics, lifestyle and nutrition; early exposures to hazardous pollutants, and bio accumulated chemicals in the environment may also associated with chronic diseases[3,4]. Although most of these chemicals leave the products or degrade in soil, water and atmosphere, some traces chemical such as heavy metals, pesticides and polycyclic aromatic hydrocarbons can be transferred to humans via food chain[5].

Contamination of food is a worldwide public health concern and may cause an economically trade problems internationally[6]. The contamination may occur through environmental pollution of the air, water and soil, or through the intentional use of various chemicals, such as pesticides, animal drugs and other agrochemicals[6]. Several studies in different countries document an exposure of toxic chemicals such as heavy metals, PAH, and OCPs in foods. In a farmland of Pearl River Estuary (China), studies confirmed that soils from this area were significantly contaminated with heavy metals. Rice and root vegetables were also polluted severely. The accumulation of Cadmium

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based on the study was the highest compared with other five metals tested[7]. Also a study from India, vegetables from the production site and market site were tested for heavy metals. Results show level of concentration of Cadmium (Cd) and Zinc (Zn) in a vegetable (spinach and cauliflower) from the production site and market site had exceeded the PFA standard and EU standards[8].

The main objective of this study is to search and summarize available evidence of Heavy metals, Polycyclic Aromatic Hydrocarbons (PAHs) and Organochlorine pesticides (OCPs) in various food products in Saudi Arabia.

METHODS

Studies published electronically from Web of Science, Google Scholar, Pub Med, and Science Direct were used in this review study. No restrictions were made from the year of publication. The search terms used included toxic substance, food products, pesticides, heavy metals and Saudi Arabia with combinations of conjunction names "and/in". We included studies determined and provide evidences of toxic substance in food products in Saudi Arabia. The variables included in the study were Heavy metals (i.e. Lead, Cadmium, and Mercury(Hg)), OCPs and PAHs. We also included studies that carried out different methods of analysis. Studies not carried out in Saudi Arabia were excluded in the study. Also, reviewed studies were excluded in this study (Figure 1).

Data were extracted from each database independently by a two researchers and assessed for inclusion/exclusion criteria. Titles and abstracts were screened for potential duplication and relevance by the two researchers. After the preliminary screening, the included studies was consulted and seen by a specialist. Details of the author of the study, toxic substance analyzed, location of the study, sample and type of food examined, equipment used and major findings were extracted from each of the studies that met the inclusion criteria.

RESULTS

Incidence of toxic substance in Saudi Arabia

A total of eight studies determined evidence of presence of toxic substance in various food products in Saudi Arabia. Findings were shown in Table 2.

Heavy Metals

Three studies determined concentration of Mercury (Hg). Cadmium (Cd), Lead (Pb), in various products in Saudi Arabia[9, 10, 11]. In a study in Riyadh (2011) examined fruit of date palm. Concentrations of Pb and Cd was determined in the dust precipitated on the surface of fruits of date palm and fruit tissue after washing. The study found residue of Pb (8.87 lg g_1 dry wt.) and Cd 1.19 lg g_1 dry wt) from washing the fruit tissue of date palm but within safe limits that was recommended by FAO/WHO[9].

The second study was carried in four city in Saudi Arabia, Tabouk, Riyadh, Dammam and Jazan[10]. The study focus on bio-monitoring contamination of heavy metals in different vegetables. In 240 samples of vegetables, results showed that leafy vegetables (parsley) contained the highest of heavy metals (543.2 and 0.048 lg/g for Fe and Hg respectively), while cucumber had the highest Pb content 6.98 lg/g on dry matter basis. Slightly high levels of mercury values ($p< 0.05$) of cucumber, tomatoes and wheat. Most of the concentration levels found in the study were above the standard permissible levels.

The third study examined the concentration of Fe, Mn, Cu, Zn, Pb, Cd and Hg in edible fish species, meat and meat products consumed in Saudi Arabia. The results showed of Lead and Cadmium (Cd) was detected in sardine at eastern district. The obtained Cd level was found above limits of 0.1 mg/kg (FAO, 1983) EC and FAO[11].

Polyclic Aromatic Hydrocarbons (PAHs)

The first study that shows an evidence of PAHs in Saudi Arabia was carried in 2002. The study use a rapid method of separation, extraction and quantitation of six carinogenic PAHs in fish samples using gas chromatography –mass spectrophotometry. The results showed Doublebar Bream 20.097mg kg–1) > Emperors (13.880 mg kg–1) > Rabbitfish (11.198 mg kg–1) > Greasy Grouper (6.273 mg kg–1) > shrimps (1.063 mg kg–1). These level were found greater than the acceptable limit (1 mg kg–1) [13].

The second study determine levels of PAHs in vegetables in major agricultural farms in Saudi Arabia. Nine variety of vegetables were examined which 80% of consumption in the region.

Table 1. Presence of toxic substance in food products in KSA

Author	Toxic substance	Location	Sample	Type of food	Equipment used	Results
Heavy Metals						
Aldjain (2011)	Lead (Pb), Cadmium (Cd)	Riyadh	One gram	Dates	Anatomic absorption spectrometer (Perkin-Elmer Model 300)	Residues from washing the fruit tissue of date palm contained amounts of Pb and Cd but within the safe limits that was recommended by FAO/WHO
Ali (2012)	Mercury (Hg). Cadmium (Cd), Lead (Pb)	Tabouk, Riyadh, Damamm and Jazan	240 samples	Vegetables, fruits and cereals	atomic absorption spectrophotometer Hydride unit was used for determination of mercury.	Leafy vegetables (parsley) contained the highest of heavy metals from middle and eastern districts. Most of the concentration levels found are above the standard permissible levels.
Alturiqi (2012)	Mercury (Hg). Cadmium, Lead	Tabouk, Riyadh, Damamm and Jazan	120 samples	Fish species, meat and meat products	Atomic absorption spectrophotometer	The highest concentration of lead and cadmium was detected in sardine at eastern district. The obtained Cd values are above the EC and FAO limits of 0.1 mg/kg (FAO, 1983)
Polycyclic aromatic Hydrocarbon (PAH)						
Ashraf (2012)	Anthracene. Benzon(a)anthracene, Benzo(e)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene,	Local wholesale suppliers/hyper markets in Saudi Arabia	Nine varieties of vegetables and fruits	Vegetables and fruits	High-performance liquid chromatography (HPLC)	Potato was biggest source of PAHs exposure followed by eggplant and carrot. For leafy vegetables,

	Benzo(a)pyrene, Dibenzo(ah)anthracene, Benzo(ghi)perylene		(355 samples)			spinach was shown at the maximum PAH level which turned to be more than any of the cores of fruit vegetables
Al Saleh (2002)	Benzo(*a*)anthracene, chrysene, benzo(*b*)fluoranthene, benzo(*a*)pyrene, indo(1,2,3,*cd*)pyrene, dibenzo(*a,h*)anthracene , benzo(*b*)chrysene, b,b-binaphthyl	Coastal Arabian Gulf waters of the Eastern province (Saudi Arabia)	54 samples 5 species	Fish	GC Mass spectrometry	Benzo(*a*)anthracene, chrysene, and benzo(*b*)fluoranthene ranged from nondetectable to 44.9mg kg–1. , while benzo(*a*)anthracene, chrysene, benzo(*b*-)fluoranthene and total PAHs greater than the acceptable tolerance limit
Organochlorine pesticides (OCPs)						
Osman (2010)	Amitrole, Anzobenzene, Bioallethrin, Biphenyl, Bromoxynil, Carbaryl, Carbofuran, Chloypyrifos, Dicofol, Dieldirin, ENT 92, Ethiofencarb, Heptenophos, Lindane, Malathion, Metalaxyl, Methoxychlor, Paraquat, Propoxur, Pyrethrin 1, Tefluthrin, Tolchflos – methyl, Warfarin	Al Qasim region	160 different domestic vegetables	Vegetables	GC Mass spectrometry	The highest concentrations were found in lettuce, followed by tomato (tolclofos-methyl, 7.312 mg/kg), cabbage (chlropyrifos, 6.207 mg/kg), carrot (heptanophos, 3.267 mg/kg), green pepper (carbaryl, 2.228 mg/kg) and egg-plant (carbaryl, 1.917 mg/ kg).
El Saeid	Dieldrin, Lindane, Chlorpyrifos, Dimenthoate,	Riyadh	Three cultivars of date	Dates	Supercritical Fluid Extraction, Microwave	Dimethoate was detected on date seeds using MSE which was

	Abamectin, Tourk, Dicol, Amitraz, Carbendazim, Benomyl, Altrazine, Glyphoshrinate, Deltamethrin, Cypermet	palm samples		Solvent, Extraction, Superfical fluid Chromotography, and GC Chromotography	detected on three date cultivars. A 0.077, 0.099, and 0.125 ppm residue level.
Homeida (2008)	DDT, HCH, Mehoxychlor, Hepatachlor epixode, Dieldrin, Endrin, Endosulfan, Lindane	Qatif, Dammam, Al - Ahsa	5 broiler farms and 10 chicken pluck shops	Chicken fat	Gas chromatography	The residues detected were well below the maximum residue limits for fat tissues according to European regulations (EEC/CD 1986).

The results of the study showed potato (2.90 ± 1.10 lg kg-1) was the biggest source of PAHs exposure followed by eggplant ant carrot (*11 lg kg-1). For leafy vegetables, spinach (10.2 lg kg-1), was shown at the maximum PAH level which turned to be more than any of the cores of fruit vegetables[12].

Organochlorine pesticides (OCPs)

Three studies carried out an evidence of toxic substance (OCPs) in various food products in Saudi Arabia. In a study in Al-Qassim region that monitor pesticide residues in vegetable grown under greenhouse conditions collected from the big supermarkets[14]. In 160 different domestic vegetables collected from four big supermarkets, residues were found in 89 samples and 53 of them were above maximum residue levels. Cabbage was the most positive and violated MLRs which eight pesticide residues were detected. Lettuce (7.648 mg/kg) has the highest concentration of ethiofencarb, followed by the fungicide tolclofos-methyl with concentration of 7.312 mg/kg in tomato.

Another study examined and analyzed residue of six pesticides in fruit Dates collected from local markets in Riyadh city. The results of the show residue level of Dimethoate was detected on date seeds on three (0.077, 0.099, and 0.125 ppm) date cultivars using Microwave Solvent Extraction (MSE) method[15].

The other study examined occurrence of organochlorine compounds in chicken meat collected from markets of Eastern Region of Saudi Arabia. The residues detected from the chicken fats were well below the maximum residue limits for according to European regulations (EEC/CD 1986)[16].

DISCUSSION

Eight studies met the inclusion criteria using an extensive search in electronic databases. Three studies determine Heavy metals in dates, fruits, vegetables and fish[9-11]; two studies show evidence of PAHs in fish and vegetables[12, 13]; three studies examined occurrence of OCPs in various local food products in Saudi Arabia[14-16].

Three studies in this review show examined and monitor Cadmium (Cd), Lead (Pb), and Mercury (Hg) level in fruits, vegetables and fish in KSA. All of the studies provides evidence

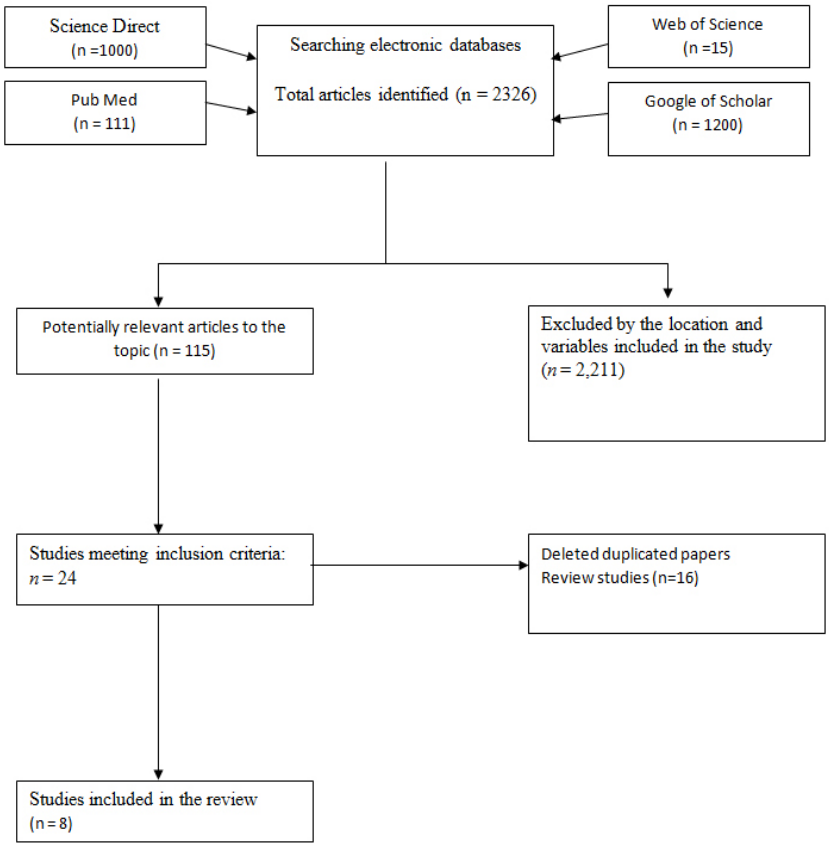

Fig. 1. Flow diagram for the selection of studies

oftraces of heavy metals in the various food products in KSA. Two of the studies show that the traces of this heavy metals were above in the recommended level[10, 11]. Leafy vegetables such as parsley and sardines were found has the highest concentration level[10]. These findings of accumulation of metals on different vegetables were also reported in a study from India, Northern Ethiopia and New Zealand[8, 17, 18]. For example, in Northern Ethiopia lettuce and tomato has a higher amounts of Cadmium[18]. Although the first study showing traces of metals in fruit dates were in recommended levels, still the source of heavy metals in KSA is unclear. Some studies reported that heavy metals accumulated more in leafy vegetables than those in other parts because these leaves considered as entry points of heavy metals from air[10]. Also heavy metals such as mercury are not easily dissolved in the environment thus it takes years and may possibly be a part or attributed in food crops.

In this review, two studies reported presence of PAHs in local food products in KSA[12, 13]. The results of this studies should be carefully considered as the findings were greater than the acceptable tolerance limit. Nevertheless, these results are similar with findings from Spain and Kuwait[19, 21]. For instance, in a study in Spain requires continuous monitoring of the trend for PAH concentrations in foodstuffs as well as the trend of dietary intake of the population[19]. Although the study in KSA was limited to a small area thus, it is sufficient to raise a concern for further studies and monitoring. Additional factors should also be considered such as cooking and food preserving. A recent study fromGhana, smoked sardines on the Ghanaian markets showed elevated levels of polycyclic aromatic hydrocarbons (PAHs)[20].

Three studies included in this review found an evidence of OCPs in KSA. The results of the study are similar from other countries. For example,

in a study that included 519 samples in Jordan, found 37% of the samples were contaminated with OCPs residues. Then a total of 15 samples were exceeded the recommended residue limits when compared to the FAO/WHO Codex Alimentarius (FAO/WHO, 2006) [22].

Another similar study conducted in Ghana, which obtain a systematic monitoring data on contamination levels of OCPs, found elevated levels of OCPs residues in fruits and vegetables collected from Ghanian markets[23]. In a study of 10 species of fishes caught in India, 22% of the fishes exceeded the maximum residue limits (MRL) of total HCH prescribed by FAO/WHO for fish products[24].

Overall, the source of the residues of toxic substance found in the eight studies is still unclear. It can be seen that it is due from environmental pollution. The data in this review further show that this toxic substance can possibly transmits and interfere into the food chain; and may cause harm to the population due to a certain disease. In one study carried out in Riyadh which measured heavy metals in placental tissue, umbilical cord and blood samples of 1578 women who delivered in one hospital[25]. Lead was detected in 96% of the placental tissues, and more than 23.7% of the women had a level less than the MDL for lead (0.25_g/g dry wt.) while cadmium was detected in 94.8% and 97.9% of cord and maternal blood samples with a mean concentration of 0.78_g/l and 0.986_g/l, respectively. Although this results are lower than the current safety level used by the American Occupational Safety and Health Administration (OSHA) of 5_g/l, thus it may raise up a concern about the long term possible adverse health effect of this toxic substance.

CONCLUSION

Even though few studies met the inclusion criteria for this review, evidence of toxic substance in various products in Saudi Arabia are still showed in this review study. Currently, the available data are not sufficient, but to raise a concern for monitoring and further studies of toxic substance in food products are needed. The authors strongly recommend further studies between association of this toxic substance and human plasma. Thus, this toxic substance may interfere in human food chain and accumulated in the body.

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