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Chemical Contaminants in Food in Pacific Island Countries

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The presence in foods of chemical contaminants such as heavy metals, pesticides, aflatoxins and polychlorinated biphenyls (PCBs) has been of international concern for decades. Since most of these are associated with intensive industrial and agricultural activity, the minimal existence of such activities in Pacific island countries has led to the conclusion that the consumption of these contaminants in food is unlikely to be a health problem in the Pacific.

Because of this little effort has been expended in studying the level of these contaminants in Pacific foods. Most of the data are from environmental studies in which some of the analytes are edible.

These have mainly been performed at the three major universities in the region, the University of the South Pacific, the University of Guam and the University of Papua New Guinea. Some data are also available from a Japanese study. More recently the United States Environmental Protection Agency has been studying sites potentially contaminated by PCBs in the former United States Trust Territories. It should be emphasized that these are scientific studies of the incidence of pollution and not country-driven analyses of the status of these pollutants in the food supply. It is also important to recognize that for the tropical Pacific islands the most important chemical food contaminants are a variety of marine toxins, especially ciguatoxins, that affect health and economies of a significant percentage of Pacific islanders.

Persistent Organic Pollutants (POPs)

The United States Environment Program has identified (initially) twelve chemicals based on their toxicity, ability for long-range transport and bioaccumulation. These are now subject to an international (Stockholm) convention signed in May, 2001 which aims to eliminate their use and production.

These include pesticides (aldrin, dieldrin, endrin, chlordane heptachlor, mirex, toxaphene and DDT), industrial chemicals (polychlorinated biphenyls and hexachlorobenzene) and chemicals produced as unwanted byproducts of industrial activity (dioxins and furans).

There are no studies in the Pacific islands concerning the occurrence of dioxins and furans in foods. These are also very expensive analyses as are those for toxaphenes, for which no data are available. The limited data for the other POPs in drinking water and foods are presented in tables that follow. Data are also included for another group of pesticides, hexachlorocyclohexanes (HCHs, one isomer of which is lindane) and for PAHs (polyaromatic hydrocarbons), another class of cancer-causing combustion side-products.

Aldrin and Dieldrin

Levels in the foods analysed range from below detection level to a maximum of less than 5 parts per billion. Even these maximum values are well below maximum residue levels established by the Codex Alimentarius Commission which range from 20-100 parts per billion depending on the type of food. This is not surprising as the use of aldrin is restricted in most countries and the need for dieldrin for termite control is also limited.

DDT

DDT and its derivatives are mainly used now for mosquito control in the countries of Vanuatu, Solomon Islands and Papua New Guinea where malaria is present. DDTs have been detected in all food samples analysed in the Pacific. Even the highest level (130 parts per billion in a meat sample from Papua New Guinea) is considerably lower than maximum recommended levels. Papua New Guinea is the only country in which reliable data in breast milk are available. Value between 60-3000 parts per billion on a fat basis were obtained. The highest value is more than double the maximum recommended level.

Heptachlor

The use of heptachlor has been severely restricted and low levels have been reported worldwide. This is also true in the Pacific islands, where even the highest level is less than one-tenth of the maximum recommended level.

Hexachlorobenzene (HCB)

This was originally used as a fungicide but in currently used in chemical manufacturing and emitted from industrial processes. None of these uses seem to have been prevalent in the Pacific islands as detected levels are very low, less than one part per billion.

HCHs and Chlordanes

The sum of the isomers of both of these insecticides in most samples did not exceed 2 parts per billion except for Solomon Island meat samples close to 10 parts per billion, which are still below what are considered maximum allowed values.

Endrin and Mirex

Few samples have been analysed for these pesticides and the few results have been below the detection levels.

PCBs

These compounds are used especially in transformer and capacitor oil. Contamination in most countries leads to high values in fish. National regulatory levels range from 500-5000 parts per billion. In Table 1 it is seen that general levels in marine samples are much lower than this. However, as seen in Table 3, recent studies at sites where contaminated electrical equipment has been disposed show high levels of PCBs. In populations whose diets consist of large amounts of fish such levels could cause serious health problems.

Heavy Metals

Lead

Table 5 shows lead levels that have been determined in various marine samples. These data have been obtained generally as an indicator of environmental pollution. The use of bivalves is problematic as they can bioaccumulate heavy metals and different species can do this to different extents. It is also not clear how capable the laboratories obtaining these data were at avoiding contamination from air borne lead-containing particles.

Mean levels (presumably wet weight) in fish and crustaceans, molluscs and fish have been reported by GEMS-Food (1987) to be between 200-250 parts per billion. On a dry weight basis this is close to 1000 parts per billion.

The data show levels in this general range although recent values in Fiji bivalves and Guam fish appear somewhat higher. There is also some indication of higher values in the late 1990s compared to the late 1980s. Given the lack of industrialisation in these countries the source of the lead is not clear. Fiji and Guam have significant per capital numbers of motor vehicles. In Fiji leaded petrol was used until the late 1990s. A recent study of river mussels in Fiji has shown lead levels 10-20 times higher in the urban areas compared to rural ones. Other heavy metals showed no such changes (Vuki, 2001).

Mercury

Like PCBs mercury is usually found in marine organisms. According to GEMS-Food (1987) typical values for seawater fish from uncontaminated waters are around 180 parts per billion or less but higher in larger carnivorous species such as tuna. Molluscs and crustacea seldom exceed 100 parts per billion. Again given that these values on a dry weight basis would be about four times higher, the reported values are in this range except for a few samples from Fiji and Guam.

Tin

Tin is a contaminant mainly introduced into the marine environment through the use of tributyl tin in antifouling paint on boats. It is not surprising then that levels are quite variable depending on the marine environment. Extremely high level of organic tin compounds have been found in sediments in Suva Harbour in Fiji as well as associated changes in sexual organs in nearby bivalves (Maata, 1994).

Aflatoxins

Aflatoxins are produced by moulds that grow on a number of nutrient-rich substrates such as nuts, maize and copra. Since mould growth is supported by warm, moist environments aflatoxin levels tend to be higher in tropical countries. Limited studies have been performed in Fiji, Vanuatu and Tonga. These do not indicate the high incidence of aflatoxins found in many other tropical countries. The food most commonly contaminated, peanuts, was the focus of these studies.

For all three countries aflatoxins were found in less than 5% of the samples studied. In Fiji the most contaminated samples were imported peanuts from Australia, indicating that the dumping by export of contaminated food may be an issue in the Pacific that warrants a monitoring program.

Conclusions

The overall knowledge of food contamination in the Pacific is limited but does not indicate serious problems. DDTs, PCBs and lead and tin have been found in a few samples above the international recommended levels and these should be the focus of further work. The level of PCBs and DDTs should especially be tested in breast milk to judge the risk to nursing infants.

Even though the limited data indicate the lack of serious contamination in the insular Pacific it is still important for the region to develop a capacity to test for these contaminants. International trade will increasing be regulated by the presence or absence of contaminants and such data need to be available to food importers and exporters.

Table 1 : Chlorinated Pesticides and PCBs in Marine Food (ng/g)

Location Food Year (samples)	HCB	HCHs	Heptachlor	Aldrin	Chlordanes	DDTs	Mirex	Dieldrin	Endrin	PCBs
Fiji Shellfish 1994 (2)	<0.1-0.1	<0.3-0.2	<0.4-0.3	<0.13	<0.5	5.0-52	<0.19	0.4-0.7	<0.5	<5.6
Tonga Shellfish 1994 (2)	<0.4	<0.8	1.0-2.3	<0.7	<0.7	2.1-2.2	<0.10	<0.1-0.6	<0.5	<1.1
Solomon Is. Fish 1992 (9)	<0.01-0.05	0.2-1.6	<0.01	<0.1-0.5	<0.01-2.1	0.07-0.83	-	0.1-2.5	-	1.2-11
Solomon Is. Crab/Oyster 1992 (4)	<0.01-0.05	0.3-0.9	0.04-0.15	<0.1-2.1	<0.01-0.8	0.3-1.4	-	0.1-0.7	-	5.9-16
PNG Fish 1992 (10)	0.01-0.1	0.2-1.9	<0.01-0.1	<0.1	0.1-0.9	0.9-24	-	0.1-1.6	-	0.1-15
Guam Mollusc 1997 (36)	-	-	-	-	-	-	-	-	-	1.2-47
Guam Fish 1997 (59)	-	-	-	-	-	-	-	-	-	0.1-85
S.I. Fish 1995 (10)	0.01-0.06	0.23-1.9	-	0.1-1.0*	0.11-1.6	0.91-24	-	0.1-1.0*	-	0.7-15
PNG Fish 1995 (13)	<0.01-0.05	0.18-1.6	-	0.1-3.0*	<0.01-2.1	0.07-1.4	-	0.1-3.0*	-	0.8-16

*Sum of aldrin and dieldrin

Table 2 : Chlorinated Pesticides and PCBs in Non Marine Food (ng/g)

Location Year (samples)	HCB	HCHs	Heptachlor	Aldrin	Chlordanes	DDTs	Mirex	Dieldrin	Endrin	PCBs
Solomon Is. Meat 1992 (2)	0.2-0.4	7.5-9.8	<0.01-0.02	<0.1-0.3	0.2-6.1	24-29	-	2.2-4.3	-	45-125
PNG Meat 1992 (2)	0.1	0.6-2.2	0.04-0.15	<0.1-1.0	0.3-0.7	4.4-130	-	2.9-3.0	-	5.2-17
Solomon Is. Cheese 1992 (1)	0.4	1.1	<0.01	<0.1	1.5	6.2	-	2.2	-	4.4
No. Marianas Roots 2000 (18)										10-230

Table 3 : PCBs and PAHs in Marine Food (ng/g wet wt.)

Location Year (samples)	HCB	HCHs	Heptachlor	Aldrin	Chlordanes	DDTs	Mirex	Dieldrin	Endrin	PCBs	PAHs
No. Mar. Clams 2000 (4)										20-24	
No. Mar. Fish 2000 (29)										17-23	
No. Mar. Crabs 2000 (100)										1-960	
No. Mar. Crabs 2001 (63)										139-492	
No. Mar. Clams 2000 (4)										20-24	
Guam Fish 2001 (28)										27-6711	
Guam Fish 1998 (53)											2-64

Table 4 : Chlorinated Pesticides and PCBs in Water (ng/L)

Location Year (samples)	HCB	HCHs	Heptachlor	Aldrin	Chlordanes	DDTs	Mirex	Dieldrin	Endrin	PCBs
Solomon Island 1992 (6)	-	0.1-5.3	-	-	<0.002-0.14	0.06-21.0	-	-	-	<0.05-1.1
No. Marianas 2000 (25)										60-32,000

Table 5 : Heavy Metals (µg/kg dry wt.)

Location Year (samples)	Lead	Mercury	Tin
Fiji Bivalve 1986 (20)	450-900	50-200	
Fiji Oyster 1988 (20)	250-5480	10-61	
Fiji Ark Shell 1992 (4)	<2000	220-560	
Fiji Ark Shell 1998 (5)	2900 - 4600	37-99	
Tonga Bivalve 1989 (5)	<500	22-191	
Vanuatu Ark Shell 1989 (4)	250-600	20-40	
Solomon Islands Fish 1993 (6)			1-280
Fiji Tuna 1992 (28)		10-970 (W)	
Guam Fish 1998 (52)	80-4200	3-1157 (W)	5-400
Guam Fish 2001 (45)	470-6000 (W)	9-45 (W)	420-790 (W)

W = wet weight

Table 6 : Analysis of Food Samples from Fiji for Aflatoxins

Food Sample		Total Number	Number Contaminated with Aflatoxin B_1	Aflatoxin B_1 Concentration of the Contaminated Samples	
				Mean (μg/kg)	Range (μg/kg)
A.	**PEANUTS**				
i)	Raw (with shell)	50	-	-	-
ii)	Raw (without shell)	8	1	639	-
iii)	Oil Fried (without shell)	125	3	254	26-667
iv)	Roasted (with shell)	100	4	359	10-1039
B.	**PEANUT BUTTER**				
i)	Locally made	50	3	39	15-85
ii)	Imported	20	-	-	-
c.	**MAIZE (Cooked)**	20	-	-	-

References

Aalbersberg, W.G.L. and Lovelace, C.E.A. (1989). Aflatoxin Levels in Foodstuffs in Fiji and Tonga Islands. Plant Foods for Human Nutrition, 39, 393-399.

Denton, G.R.W., Wood, H.R., Concepcion, L.P., Siegrist, H.G., Eflin, V.S., Narcis, D.K. and Pangelinan, G.T. (1997). Analysis of In-Place Contaminants in Marine Sediments from Four Harbor Locations on Guam. A Pilot Study. WERI Technical Report No. 81, 120pp.

Dolodolotawake, U. (1999). Dietary Aflatoxins and the Incidence of Liver Cancer in Indigenous Fijians. MSc thesis, University of the South Pacific, Suva, Fiji.

Denton, G. (2001). WERI Technical Report xx, Guam EPA, in press.

Harrison, N., Gangaiya, P. and Morrison, R.J. (1996). Organochlorines in the Coastal Marine Environment of Vanuatu and Tonga, Marine Pollution Bulletin, 32(7), 575-579.

IAS (1992). Report to Pacific Fishing Company, unpublished report.

Iwata, H., Tanabe, S., Sakai, N., Nishimura, A. and Tatsukawa, R. (1994). Geographical Distribution of Persistent Organochlorines in Air, Water and Sediments from Asia and Oceania, and their Implications for Global Redistribution from Lower Latitudes, Environmental Pollution, 85, 15-33.

Kannan, K., Tanabe, S. and Tatsukawa, R. (1995). Geographical Distribution and Accumulation Features of Organochlorine Residues in Tropical Asia and Oceania, Environ. Sci. Technol., 29, 2673-2683.

Kannan, K., Tanabe, S., Williams, R.J. and Tatsukawa, R. (1994). Persistent Organochlorine Residues in Foodstuffs from Australia, Papua New Guinea and the Solomon Islands: Contamination Level and Human Dietary Exposure, The Science of the Total Environment, 153, 29-49.

Maata, M. (1994). TBTs in Fiji Marine Sediments, Ph.D. thesis, University of the South Pacific, Suva, Fiji.

Morrison, R.J., Harrison, N. and Gangaiya, P. (1996). Organochlorine Contaminants in the Estuarine and Coastal Marine Environment of the Fiji Islands, Environmental Pollution, 93(2), 159-167.

Morrison, R.J., Narayan, S.P. and Gangaiya, P. (2001). Trace Element Studies in Laucala Bay, Suva, Fiji, Marine Pollution Bulletin, in press.

Naidu, S.D. and Morrison, R.J. (1994). Contamination of Suva Harbour, Fiji, Marine Pollution Bulletin, 29, 126-130.

Petr, T. (1980). Purari River Environment (Papua New Guinea): A Summary Report of Research and Surveys during 1977-1979, unpublished report.

USEPA (2001). Heavy Metals and PCBs in Fish in the Vicinity of Orote Point, Guam, unpublished report.

USEPA (2001). PCB Survey of Tanapag Village, Northern Marianas, unpublished report.

Vuki, M. (2001). Heavy Metals in Kai (*Batissa violacea*) in the Rewa River, unpublished results.