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Organochlorine Pesticide Residues in Human Milk in the Ribeirão Preto Region, State of São Paulo, Brazil[1]

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Abstract. Thirty-seven samples of human milk (colostrum) from donors living in the Ribeirão Preto region were analyzed to determine the levels of organochlorine pesticide residues. Donors were classified into two groups, i.e., occupationally exposed and non-exposed to pesticides. Other factors such as age, previous lactations, race, smoking habit, occupation, family income and educational level were also considered. Analysis was performed by preliminary lipid extraction followed by fractional partition on a column and finally by gas chromatography with an electron capture detector. Lindane was found in 32% of the samples in amounts of less than 0.001 mg/kg; heptachlor was found in 65% of the samples at mean levels of 0.001 mg/kg, *i.e.*, a level five-fold lower than that established by FAO/WHO (1970) for cow's milk. Aldrin and endrin were not detected in any of the samples. Dieldrin was detected in only one sample at a level of 0.038 mg/kg, which is considered high. DDT and DDE amounts are reported as total DDT and at least one of these compounds was present in every sample. Amounts detected in donors occupationally exposed to pesticides ranged from 0.008 to 0.455 mg/kg (mean, 0.149 mg/kg), *i.e.*, three times the limit established by FAO/WHO (1970), while values for donors who had not been exposed ranged from 0.002 to 0.072 mg/kg (mean, 0.025 mg/kg), *i.e.*, half the limit. Considering the level of acceptable daily intake proposed by FAO/WHO (1973), lactents ingested 1% of the acceptable intake of lindane (all donors), 30% of the acceptable intake of heptachlor (all donors), 60% of the acceptable intake of DDT (non-exposed donors), and 3.7 times the acceptable intake of DDT (exposed donors). Comparing the present results with those obtained 10 years ago, the total DDT level in human milk is decreasing in this part of the country. The mean amount of organochlorine residues in non-exposed women's milk was one of the lowest levels among those recorded in the literature. DDT levels of occupationally exposed women's milk were comparable with those reported for developed countries and lower than those detected in Latin American countries. When the results of this survey are considered in relation to the advantages of breast-feeding, the risk-benefit balance is still favorable to breast-feeding. However, given the lack of long-term epidemiological studies, undesirable or harmful long-lasting effects cannot be excluded.

Research carried out in different parts of the world and studies performed by international organizations have demonstrated that organochlorine pesticides are present in the human body, where they preferentially accumulate in adipose tissue and in the lipidic substances of fluids (Egan *et al.* 1965; Curley and Kimbrough 1969; Tanabe 1972; Kutz *et al.* 1977). Man, at the top of the food chain, tends to accumulate greater quantities of these residues due to the biomagnification phenomenon (Edwards 1970; Matsumura 1972). Part of the human population is also occupationally exposed to these compounds.

Thus far, there are insufficient data to permit the establishment of a relationship between the residues of these substances and human pathological conditions, but many clues have led researchers to be concerned with this possibility. In some studies, larger amounts of organochlorine pesticides have been detected in the adipose tissue of patients who died of primary carcinoma of the liver, leukemia and portal cirrhosis, than in control patients. A greater accumulation of these compounds has also been detected in patients who died of neurological disorders (Albert 1981).

The greatest concern, however, is caused by the fact that organochlorine residues are excreted into human milk in appreciable amounts (Olszyna-Marzys *et al.* 1973; Hayes 1975). Mother's milk, the only food of newborn infants, is

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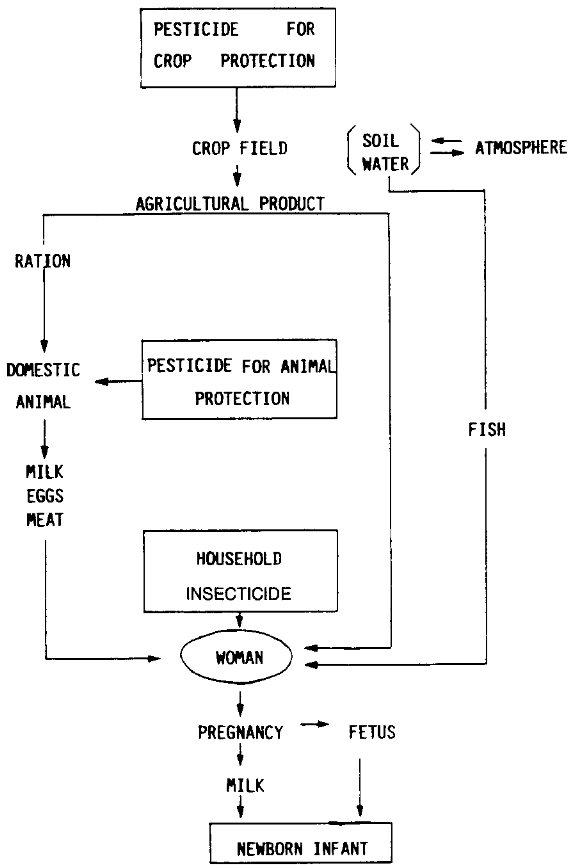

Fig. 1. Route of pesticide residue transfer to newborn infant (Yamaguishi *et al.* 1972)

consumed in amounts proportionally quite elevated and represents the main route of transfer of these residues to the children in addition to transplacental passage (Figure 1). The presence of contaminants in such an essential food represents a source of strong concern. In developing countries, in which the economy is predominantly agricultural, several factors contribute to the expectation of higher levels of residues; among them, the inappropriate use and poor regulation of agricultural pesticides and the need for massive use of insecticides in public health programs (Fahim *et al.* 1970).

Since the first report on the presence of DDT in human milk in 1951, a number of studies have been carried out in almost all regions of the globe.

In Brazil, the first study on DDT and DDT metabolite residues in human milk was made by Matuo (Matuo 1978). The results indicated that contamination of human milk in the Ribeirão Preto region was comparable to that observed in most developed countries, ranging from 0.2 to 6.38 times the limit values established by FAO/WHO for cow's milk.

The present study was undertaken to determine the possible presence in human milk of other organochlorine pesticides intensely utilized in the agricultural production of the region, such as lindane, heptachlor, aldrin, dieldrin and endrin in addition to DDT.

Thus, the objective was to determine the present status of human milk contamination by organochlorine pesticides in this region and to compare the levels of this contamination between women with different types of exposure.

Material and Methods

Human milk samples were collected from 30 newly delivered women admitted to the University Hospital of Ribeirão Preto from October 1983 to February 1984. Seven samples were also collected from donors from the municipality of Jaboticabal (Santa Isabel Hospital) who had been occupationally exposed to pesticides. All samples were collected at the two hospitals on the morning of the 2nd or 3rd postpartum day.

Questionnaires were presented to the donors to identify and determine the type of exposure, especially occupational exposure to pesticides.

The donors that were not occupationally exposed were divided into groups according to color, age, profession, educational level, family income, smoking habit and previous lactations. Occupationally exposed donors, who formed a homogeneous group, were considered as a single group.

The analytical method, previously employed by Matuo (1978) and adapted to that of Almeida and Barreto (1971), consisted of the following steps: lipid and pesticide extraction, extract fractionation and fraction purification. Chromatographic analyses were performed with a gas chromatography apparatus equipped with an electron capture detector, using P grade (high purity) nitrogen as the gas phase.

Two columns were used. The first, used for the detection of lindane, heptachlor, aldrin, dieldrin and endrin, was a 0.32×150 cm stainless steel column with 1.5% OV − 17 + 1.95% QF − 1 as the stationary phase, and Chromosorb W-HP support. Column temperature was 169°C, vaporizer temperature 220°C, and detector temperature 207°C. The gas phase was N_2, and the flow rate 30 ml/min.

For a better separation of DDE, TDE, DDT and dieldrin, we used a second 0.32×150 cm glass column with 3% SE-30 + 2% DC 200 as the stationary phase and Chromosorb W-HP support. Column temperature was 177°C, vaporizer temperature 220°C and detector temperature 207°C. The gas phase was N_2, and the flow rate 30 ml/min.

The pesticides were identified by comparing the retention times obtained for the chromatograms of the samples with those obtained for the chromatograms of standard substances analyzed under identical conditions.

Quantitative determination was performed by comparing the areas of the peaks obtained for the chromatograms of the samples with those obtained for the chromatograms of the standards taking into consideration the purity factor.

Concentrations were expressed as mg substance/kg milk, corresponding to parts per million (ppm).

Results

The levels of the organochlorine pesticide residues detected in the milk from the 30 non-occupationally exposed donors and from the seven occupationally exposed donors are presented in Table 1.

Lindane residues (γ-HCH) were detected in 32% of the samples at very low levels not exceeding 0.001 mg/kg. Heptachlor residues were detected in 65% of the samples at mean levels of 0.001 mg/kg, and only one sample showed a level above the extraneous residue limit (ERL).

Dieldrin was detected in a single sample and at a relatively high level (0.038 mg/kg). Aldrin and endrin were not detected in any sample.

As to total DDT (*p,p'*-DDE + *p,p'*-DDT), all samples presented some residues. Total DDT levels ranged from 0.002 to 0.072 mg/kg (mean = 0.025 mg/kg) in non-occupationally

Table 1. Organochlorine residues in human milk (colostrum) of occupationally non-exposed (N) and exposed (E) donors of the Ribeirão Preto region, State of São Paulo, Brazil (1983/1985)

Donor No	Age	Color[a]	Profession[b]	No of previous lactations	NB[e] weight (g)	Concentration (mg/kg or ppm) Lindane	Heptachloride	p,p'-DDE	p,p'-DDT	Total DDT
N 1	28	W	M	3	3460	tr[c]	0.003	0.011	0.009	0.020
N 2	21	B	HW	0	3280	ND[c]	tr	0.001	0.001	0.002
N 3	17	W	HW	0	3410	ND	0.001	0.002	0.016	0.018
N 4	29	B	M	5	2270	0.001	0.002	0.063	0.005	0.068
N 5	21	M	M	1	3200	ND	tr	0.008	0.002	0.010
N 6	27	M	NT	0	3620	ND	0.001	0.046	0.005	0.051
N 7	38	W	RW	4	3820	tr	0.003	0.006	0.001	0.007
N 8	27	B	HW	6	4450	ND	0.002	0.065	0.002	0.067
N 9	34	M	M	1	3400	ND	0.001	0.053	0.019	0.072
N 11	19	W	HW	0	3160	0.001	ND	0.004	0.002	0.006
N 12	25	B	HW	2	2710	tr	0.001	0.021	0.012	0.033
N 13	20	M	M	0	3200	ND	ND	0.002	0.003	0.005
N 14	31	W	HW	0	3960	ND	0.020	0.027	0.011	0.038
N 15	22	W	M	0	3000	tr	ND	0.015	0.003	0.018
N 16	20	B	HW	0	3030	ND	tr	0.006	0.002	0.008
N 17	22	W	M	0	3400	tr	0.001	0.020	0.003	0.023
N 18	21	W	HW	0	3520	ND	ND	0.022	0.015	0.037
N 20	35	W	HW	3	3600	ND	ND	0.010	ND	0.010
N 21	34	M	HW	4	2100	ND	0.002	0.017	0.002	0.019
N 22	31	B	HW	3	2750	ND	ND	0.011	0.002	0.013
N 23	27	B	M	4	2850	ND	0.001	0.015	0.003	0.018
N 24	34	W	C	2	3230	ND	0.001	0.020	0.001	0.021
N 25	22	W	HW	1	2410	ND	0.001	0.010	0.001	0.011
N 26	24	M	B	1	4100	ND	ND	0.018	0.006	0.024
N 27	18	W	M	0	4190	ND	0.003	0.037	0.008	0.045
N 28	26	M	M	2	3760	ND	0.002	0.017	0.006	0.023
N 29[d]	17	W	HW	0	3000	tr	0.002	0.014	0.023	0.037
N 30	23	W	ET	0	2950	ND	ND	0.004	0.004	0.008
N 31	31	W	UP	0	—	ND	0.002	0.009	0.001	0.010
N 32	19	M	HW	1	2880	tr	0.002	0.034	0.019	0.053
Mean (N)							0.020	0.019	0.006	0.025
E 1	21	W	RW	0	3620	ND	ND	0.024	0.049	0.073
E 2	16	W	RW	0	2830	tr	0.001	0.040	0.060	0.100
E 3	18	M	RW	0	2500	ND	ND	0.020	0.154	0.174
E 4	20	W	RW	1	2540	tr	ND	0.033	0.067	0.100
E 5	21	W	RW	2	2430	ND	ND	0.053	0.402	0.455
E 6	27	W	RW	1	2880	tr	0.001	0.042	0.098	0.140
E 7	24	M	RW	2	2800	ND	ND	0.001	0.007	0.008
Mean (E)								0.030	0.119	0.149

[a] W = white; M = mulatto; B = black
[b] M = maid; HW = housewife; C = charwoman; B = brickmaker; ET = elementary schoolteacher; UP = university professor; RW = rural worker; NT = nurse technician
[c] tr = traces; ND = not detected
[d] The only donor who presented dieldrin residues (0.038 mg/kg)
[e] NB = newborn

exposed donors and from 0.008 to 0.455 mg/kg (mean = 0.149 mg/kg) in occupationally exposed donors.

Discussion

Lindane

The lindane (γ-HCH) levels were quite low (0.001 mg/kg) when compared to those reported for the United States (Barnett *et al.* 1979), Japan (Yamamoto *et al.* 1975, 1979) and Australia (Stacey *et al.* 1985).

Both lindane and BHC (a mixture of α, β, and γ-HCH isomers) have been extensively used in agriculture and also for the control of cattle ectoparasites. The use of these substances was forbidden in 1971 (Ministério da Agricultura 1971) for pastures, in 1980 (Ministério da Agricultura 1980) for vegetables and then fully prohibited for agricultural use in 1985 (Ministério da Agricultura 1985). The use of BHC by The Superintendent Office of Public Health Campaigns (SUCAM) is still permitted for the control of triatomides transmitting Chagas' disease.

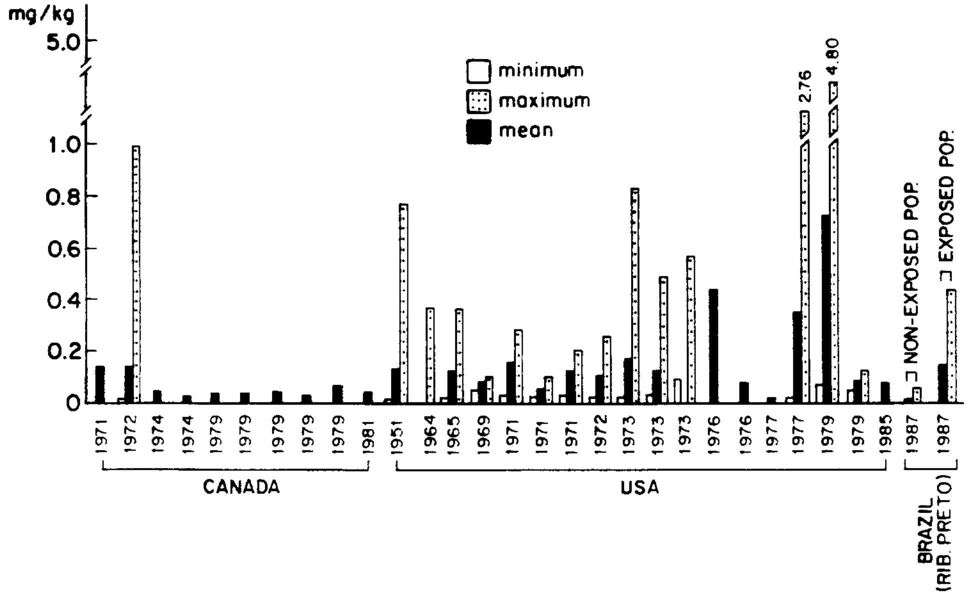

Fig. 2. Total DDT residue levels in human milk (colostrum) in the Ribeirão Preto region compared to those detected in Canada and in the USA

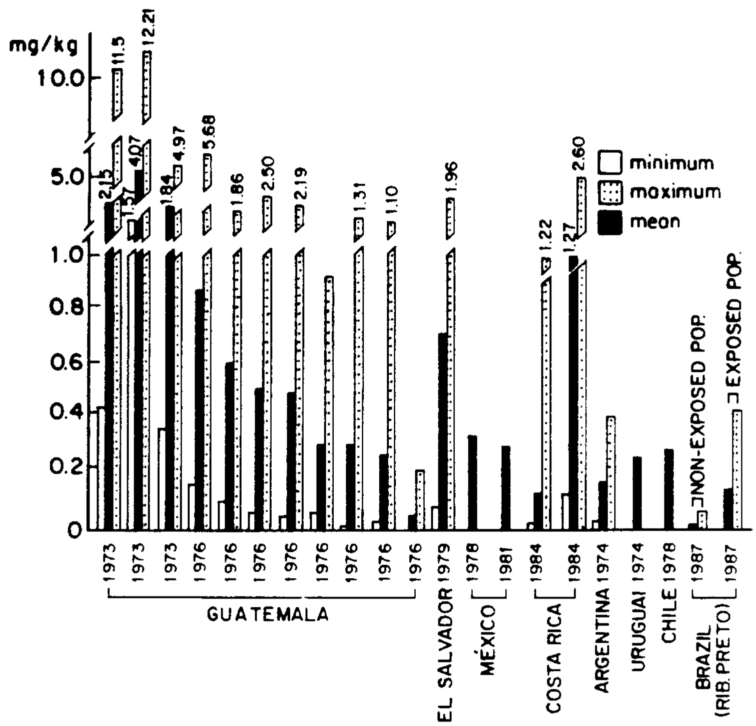

Fig. 3. Total DDT residue levels in human milk (colostrum) in the Ribeirão Preto region compared to those detected in other Latin American countries. [The data of Lara *et al.* (1982) were not presented in the figure because they were expressed in units not comparable to the others]

Several studies (Kucinski 1986) have pointed out the presence of organochlorine residues in different food groups (meat, dairy products, milk, grains, and stimulating drinks). These foods, which represent the basic staples for the donors studied here, may explain the presence of lindane in their milk.

Cyclodienes

The mean heptachlor level in the 37 samples was 0.001 mg/kg and the frequency of positive samples was 65%. A survey by Jensen (1983) indicates that the frequency reported in most studies is about 50% of the samples.

The mean heptachlor levels are similar to those reported in the United States (Curley and Kimbrough 1969; Jonsson *et al.* 1977; Barnett *et al.* 1979), Canada (Mes and Davies 1979), Uruguay (Bauzá 1975), Belgium (Heyndrickx and Maes 1969), Norway (Bakken and Seip 1976), and The Netherlands (Tuinstra 1971).

Dieldrin was detected in a single sample at a relatively elevated level (0.038 mg/kg) comparable to the mean levels detected in Australia (Miller and Fox 1973) and Iraq (Al-Omar *et al.* 1985) and to the maximum levels detected in Portugal (Graça *et al.* 1974). According to Jensen (1983), the detection of dieldrin in human milk has not been frequent, especially in more recent reports. The occurrence of dieldrin

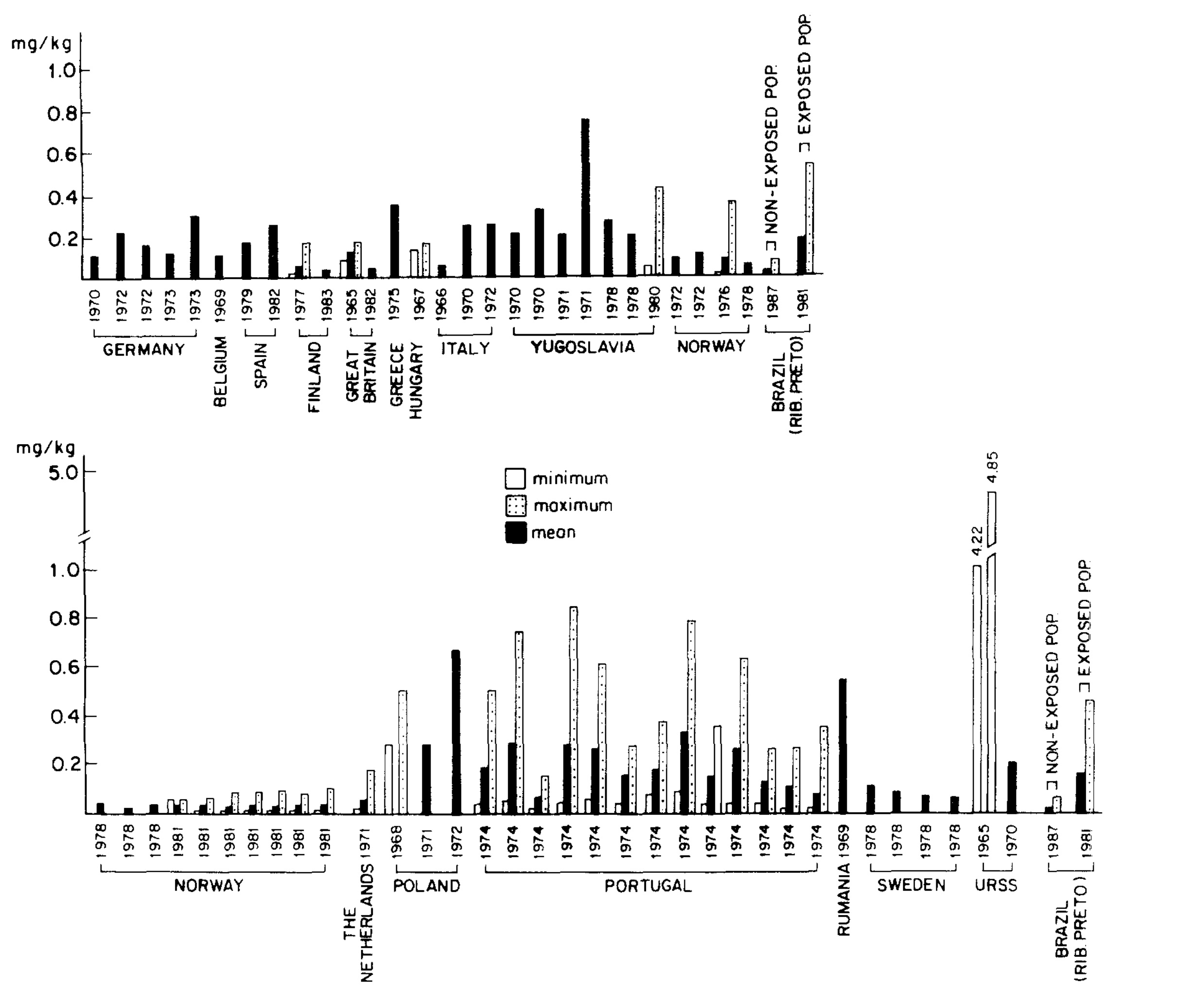

Fig. 4. Total DDT residue levels in human milk (colostrum) in the Ribeirão Preto region compared to those detected in European countries

in 100% of samples has been reported in earlier papers, a fact that may have been related to the problem of identification of the compound on the chromatogram. The retention time of dieldrin is almost identical to that of *p,p'*-DDE.

Aldrin and endrin residues were not detected in any sample. Since aldrin is rapidly metabolized to dieldrin in the human body (Jager 1970; Ackerman 1980), this residue is not expected to be found in its original form but rather as its metabolite.

The present data do not provide an explanation for the fact that only one sample presented dieldrin residues and at a relatively elevated level. In Australia, where dieldrin, aldrin, heptachlor and chlordane are systematically used for residential termite proofing according to official recommendations, high levels of residues of these substances have been detected, and of dieldrin in particular (Stacey and Tatum 1985). In Brazil, termite proofing is not a usual practice, but the hypothesis that the donor who presented dieldrin residues was exposed to aldrin used for termite exterminating purposes cannot be ruled out.

In Brazil, the agricultural use of these pesticides was permitted until 1985 (Ministério da Saúde 1985), with intensive applications in all agricultural areas, including Ribeirão Preto.

Cyclodiene metabolization and elimination is relatively more rapid than for DDT, with heptachlor residues decreasing considerably five months after exposure (Stacey and Tatum 1985). Jager (1970) indicated that the half-life of endrin is 24 hours and the half-life of dieldrin, approximately 8 months.

In the group of exposed donors, a larger number of samples was expected to present more significant levels of heptachlor and aldrin (dieldrin) residues since these pesticides are routinely used for the planting of sugar cane, an activity in which the donors had been engaged for some time in the Ribeirão Preto region where this crop predominates. Perhaps the fact that sugar cane is planted in this region every 3 or 4 years and that planting is performed more often by fixed farm laborers may explain the low concentrations detected.

DDT

DDT is the organochlorine compound most extensively studied and detected at the highest levels together with its metabolites. Figures 2 through 6 present comparisons of the data obtained for the occupationally exposed and non-

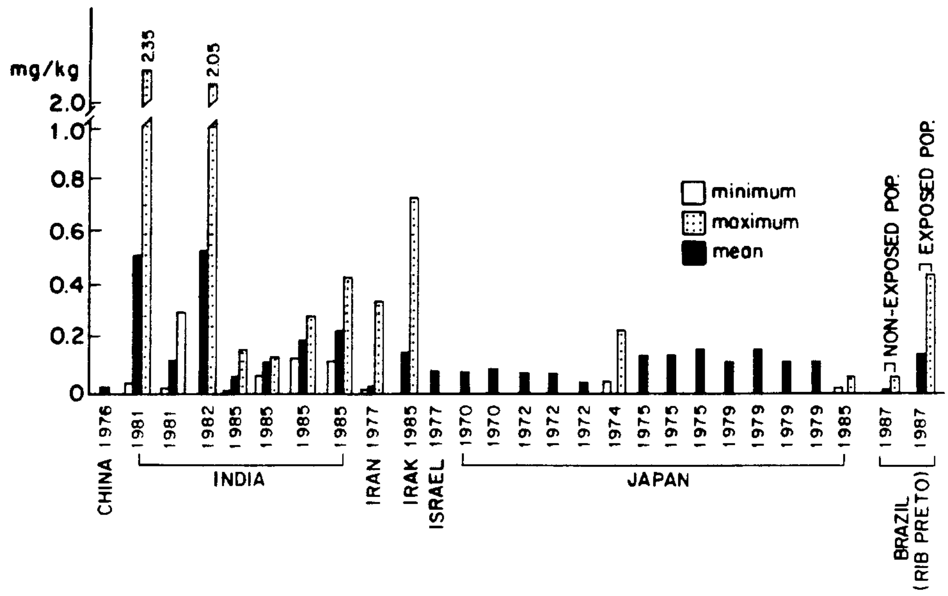

Fig. 5. Total DDT residue levels in human milk (colostrum) in the Ribeirão Preto region compared to those detected in Asian countries

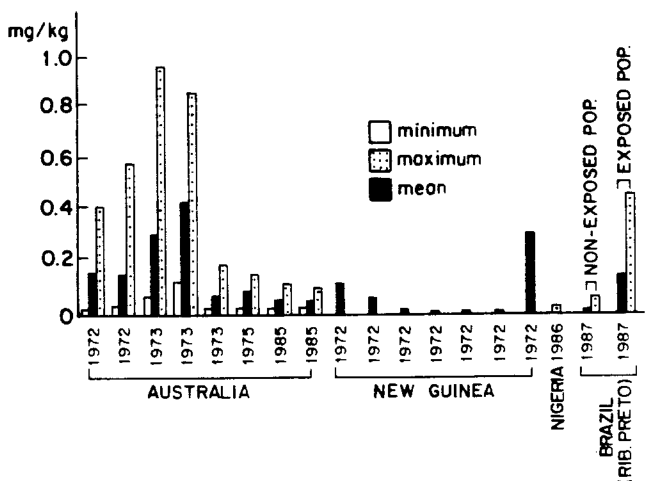

Fig. 6. Total DDT residue levels in human milk (colostrum) in the Ribeirão Preto region compared to those detected in Oceania and in African countries

exposed donors from the region of Ribeirão Preto, Brazil, with those obtained for the United States and Canada, Latin America, Europe, Asia, Africa, and Oceania.

The total DDT (*p,p'*-DDT + *p,p'*-DDE) levels detected in non-occupationally exposed donors were slightly higher in non-whites and in whites in the 26–30 year age range. When profession, educational level and family income are considered, the high DDT levels detected in this donor group are not related to the social condition of the donor. Also, no differences were detected between smokers and non-smokers, a result possibly explained by the fact that the use of DDT was prohibited in Brazilian tobacco plantations in 1972 (Ministério da Agricultura 1972).

Also, there were no differences in results in relation to previous breast-feeding. This relationship between total level of excreted DDT and breast-feeding was examined because in a previous study Matuo (1978) detected, as also reported by Kroger (1972), that primiparae presented higher DDT concentrations than multiparae, *i.e.*, than women who had had more children and therefore had breast-fed more frequently. If one assumes that lactation is an effective route for the excretion of DDT residues, the colostrum of primiparae would be expected to present larger amounts of residues. However, other investigators in Hawaii (Takahashi *et al.* 1981) and Canada (Dillon *et al.* 1981) found no association between previous lactations and level of DDT residues.

The group of occupationally exposed donors, although small, presented several characteristics in common. All were farm laborers, three lived and worked in the rural zone, and the other four lived in the city but went to work daily in the fields (day laborers).

Mean time of work in the field was 7.5 years, involving crops such as peanuts, cotton, oranges, and sugar cane, with a predominance of the last two. Aldrin or heptachlor was used systematically during the sugar cane planting phase to fight soil pests (termites). When working with the cotton crop, the donors may have been exposed to DDT since its use was forbidden only in 1985. DDT, γ-HCH (lindane) or cyclodienes are not traditionally used for the orange crop. For peanuts, DDT may have been employed for pest control, although this is not a common practice.

p,p'-DDT levels were higher than *p,p'*-DDE levels, an interesting fact that demonstrated that the workers had been exposed more or less recently to DDT. *p,p'*-DDT is known to degrade slowly into *p,p'*-DDD and *p,p'*-DDE, the latter being its main metabolite stored in man; the time for *p,p'*-DDT to be metabolized to *p,p'*-DDE is approximately one year (Jonsson *et al.* 1977).

The most probable hypotheses are that these donors weeded recently treated cotton fields and/or harvested peanuts, crops that may have been treated with DDT. Another hypothesis is that houses were treated with DDT for the control of malaria. However, the data obtained did not indicate that DDT was sprayed during the study period for this purpose.

Table 2. Frequency of the occurrence of organochlorine pesticide residues in human milk in relation to extraneous residue limits (ERL). Ribeirão Preto, State of São Paulo, Brazil (1983/1985)

								Observed values/Limits			
			Observed values (O.V.)					In milk		In milk fat	
	ERL[b] (mg/kg)		In milk		In milk fat[a]		Frequency of positive	X O.V.	Max. O.V.	X O.V.	Max. O
Pesticide	In milk	In milk fat	Mean	Max.	Mean	Max.	samples	ERL	ERL	ERL	ERL
Lindane (N and E)[c]	0.004[d]	0.10[ef]	—	0.001	—	0.034	32%	—	0.2	—	0.
Heptachloride (N and E)	0.005[d]	0.15[e] 0.01[f]	0.001	0.020	0.048	0.670	65%	0.3	4.0	0.3 4.8	4. 69.
Dieldrin (N and E)	0.005[d]	0.15[ef]	—	0.036	—	1.310	3%	—	7.6	—	8.
DDT (N and E)	0.050[d]	1.25[ef]	0.049	0.455	1.669	15.689	100%	1.0	9.1	1.3	12.
DDT (N)	0.050[d]	1.25[ef]	0.025	0.072	0.862	2.462	100%	0.5	1.4	0.7	2.
DDT (E)	0.050[d]	1.25[ef]	0.149	0.455	5.138	15.689	100%	3.0	9.1	4.1	12.

[a] Considering 2.9% fat in colostrum
[b] ERL = extraneous residue limit
[c] N = occupationally non-exposed; E = occupationally exposed
[d] FAO/WHO (1970)
[e] FAO/WHO (1973)
[f] Ministério da Saúde (1985) (Brazil)

Table 3. Frequency of occurrence of organochlorine pesticides in human milk in relation to Acceptable Daily Intake (ADI), Ribeirão Preto, State of São Paulo, Brazil (1983/1985)

		Observed values (mg/kg)						
	Acceptable daily intake (ADI)[d]	In milk		In milk fat[a]		Frequency of positive	Observed intake/ADI[b]	
Pesticide	(mg/kg/day)	Mean	Maximum	Mean	Maximum	samples	Mean	Maximum
Lindane (N and E)[c]	0.0125	—	0.001	—	0.034	12%	—	0.01
Heptachloride (N and E)	0.0005	0.001	0.020	0.048	0.700	65%	0.3	5.0
Dieldrin (N and E)	0.0001	—	0.038	—	1.310	3%	—	47.5
DDT (N and E)	0.0050	0.049	0.455	1.689	15.689	100%	1.2	11.4
DDT (N)	0.0050	0.025	0.072	0.862	2.482	100%	0.6	1.8
DDT (E)	0.0050	0.149	0.455	5.138	15.689	100%	3.7	11.4

[a] Considering 2.9% fat in colostrum
[b] Considering a daily ingestion of 125 g milk/kg
[c] N = occupationally non-exposed; E = occupationally exposed
[d] FAO/WHO (1973)

Organochlorine Levels Detected in Human Milk and Legal Limits

When lindane (γ-HCH) concentrations were calculated (0.001 mg/kg), the level of this compound in the samples was found to be 4 times lower than acceptable limits. Calculating the amount of lindane in milk fat, the concentration would be 0.0344 mg/kg, *i.e.*, 34% of the ERL.

Mean heptachlor levels were quite low, approximately 3 times lower. The maximum value detected (0.020 mg/kg) exceeded 4 times the ERL for whole milk and 4.6 times the ERL for milk fat.

However, if we consider the ERL for milk fat established by the Health Ministry of Brazil (Ministério da Saúde 1985), the maximum value detected in the present study exceeded the limit 69 times, *i.e.*, the Brazilian limit is 15 times more rigorous than the international limit. It is possible that there was an oversight in the Brazilian law or in its publication, since the limits for the residues of other organochlorine compounds in milk fat cited in the present paper closely follow those established by FAO/WHO (1970, 1973) (Table 2).

Dieldrin, which was detected in only one sample (N29), exceeded the ERL 7.6 times when calculated for milk and 8.8 times when calculated for colostrum fat.

The mean DDT level detected for the 37 samples as a whole (from exposed and non-exposed women) was 0.049 mg/kg, a value close to the ERL for cow's milk (0.05 mg/kg). The maximum value observed, however (0.455 mg/kg), exceeded the ERL for milk 9.1 times and the ERL for milk fat 12.6 times.

Table 3 shows the Acceptable Daily Intake of different organochlorine compounds by the lactents and the relationship with the respective Acceptable Daily Intakes (ADIs).

Assuming a daily milk consumption of 125 g/kg and the fat level to be 2.9%, and calculating daily lindane ingestion for the maximum value of 0.0344 mg/kg in milk fat by the formula suggested by the WHO (43), the value of 0.000112 mg/kg/day is obtained. This value is 100 times below the ADI of 0.0125 mg/kg established by FAO/WHO (1973).

When the same calculations are made for heptachlor, only the maximum value exceeds the ADI, *i.e.*, only the lactent of donor N14 ingested heptachlor concentrations 5 times above the ADI.

The only dieldrin value detected in the sample (N29), 0.038 mg/kg, exceeded 47.5 times the ADI for this compound. We consider this finding to be important because studies carried out on fish have demonstrated evidence that the response to the dieldrin dose is a quantitative function of body size and, therefore, the dose-response relationship should differ among individuals of different sizes, in this case, newborn infants and adults (Lara *et al.* 1981).

Considering the mean DDT value observed in the 37 samples, the lactents of these mothers are ingesting on average 1.2 times the ADI. The lactents of non-exposed mothers are ingesting on average 0.6 times the ADI and a maximum of 1.8 times the ADI, whereas the lactents of exposed mothers are ingesting on average 3.7 times the ADI and a maximum of 11.4 times the ADI.

A previous study carried out by Matuo (1978) in the same region on 24 milk samples showed a mean level of total DDT of 0.090 mg/kg. In the present study, the overall mean for the samples analyzed, including exposed and non-exposed donors, was 0.049 mg/kg. In the previous study, excluding two occupationally exposed donors, it was possible to calculate the mean DDT level for non-exposed donors, which was 0.086 mg/kg, *i.e.*, a value much higher than the mean for the non-exposed donors of the present study, which was 0.025 mg/kg. These data appear to indicate a decrease in contamination during this period, which possibly reflects the restrictive measures imposed on the use of organochlorine compounds. However, the number of samples is not large enough to support this statement.

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References

Ackerman LB (1980) Overview of human exposure to dieldrin residues in the environment and current trends of residue in tissue. Pest Monit J 14:64–69

Albert L (1981) Residuos de plaguicidas organoclorados en leche materna y riesgo para la salud. Bol Oficina Panam Salud 91:15–29

Almeida MEW, Barreto HHC (1971) Resíduos de pesticidas clorados em leite consumido em São Paulo. Rev Instit Adolfo Lutz 31:13–20

Al-Omar M, Tawfiq SJ, Al-Ogaly N (1985) Organochlorine residue levels in human milk from Baghdad. Bull Environ Contamin Toxicol 35:65–67

Bakken AF, Seip M (1976) Insecticides in human breast milk. Acta Paediatr Scand 65:535–539

Barnett RW, D'Ercole AJ, Cain JD, Arthur RD (1979) Organochlorine pesticide residues in human milk samples from women living in Northwest and Northeast Mississippi, 1973–75. Pest Monit J 13:47–51

Bauzá CA (1975) Resíduos de plaguicidas organoclorados en leche de madres de Montevideo. Arch Pediatr Uruguay 46:31–42

Curley A, Kimbrough R (1969) Chlorinated hydrocarbon insecticides in plasma and milk of pregnant and lactating women. Arch Environ Health 18:156–64

Dillon JC, Martin GB, O'Brien HT (1981) Pesticides residues in human milk. Food Cosmetics Toxicol 19:437–42

Edwards CA (1970) Persistent pesticides in the environment. CRC Press, Cleveland, 78 pp

Egan H, Goulding R, Roburn J, Tatton Jo'G (1965) Organochlorine pesticide residues in human fat and human milk. Br Med J 2:66–69

Fahim MS, Bennett R, Hall DG (1970) Effect of DDT on the nursing neonate. Nature 228:1222–1223

FAO/WHO (1970) Residuos de plaguicidas en los alimentos. Ginebra, Organización Mundial de la Salud (Série de Informes Técnicos 458), 50 pp

(1973) Residuos de plaguicidas en los alimentos. Ginebra, Organización Mundial de la Salud (Série de Informes Técnicos 525), 65 pp

Graça IG, Silva Fernandes AMS, Mourão HC (1974) Organochlorine insecticide residues in human milk in Portugal. Pest Monit J 8:148–54

Hayes WJ (1975) Toxicology of pesticides. Williams and Wilkins, Baltimore, 580 pp

Heyndrickx A, Maes R (1969) The excretion of chlorinated hydrocarbon insecticides in human mother's milk. J Pharm Belg 24:459–463

Jager KW (1970) Aldrin, dieldrin, endrin and telodrin—An epidemiological and toxicological study of long-term occupational exposure. Elsevier, Amsterdam, 234 pp

Jensen AA (1983) Chemical contaminants in human milk. Residue Rev 89:1–128

Jonsson V, Liu GJK, Ambruster J, Kettelhut LL, Drucker B (1977) Chlorohydrocarbon pesticide residues in human milk in Greater St. Louis, Missouri 1977. Am J Clin Nutr 30:1106–1109

Kroger M (1972) Insecticide residues in human milk. J Pediatr 80:401–405

Kucinski B (1986) O veneno nosso de cada dia. Ciência Hoje 4:58–62

Kutz FW, Yobs AR, Strassman SC (1977) Racial stratification of organochlorine insecticide residues in human adipose tissue. J Occupational Med 19:619–622

Lara WH, Barreto HHC, Varella Garcia M (1981) Níveis de dieldrin em sangue de aplicadores de aldrin na região de São José do Rio Preto, São Paulo. Rev Inst Adolfo Lutz 41:9–14

Matsumura F (1972) Current pesticide situation in the United States. In: Matsumura F, Boush GM, Misato T (eds) Environmental toxicology of pesticides. Academic Press, NY, pp 33–60

Matuo YK (1978) DDT levels in maternal milk in the Ribeirão Preto region. Master's thesis, Nursing School of Ribeirão Preto, USP, 71 pp

Mes J, Davies D (1979) Presence of polychlorinated biphenyl and organochlorine pesticide residues and the absence of polychlorinated terphenyls in Canadian human milk samples. Bull Environ Contam Toxicol 21:381–387

Miller GJ, Fox JA (1973) Chlorinated hydrocarbon pesticide residues in Queensland human milks. Med J Australia 2:261–264

Ministério Da Agricultura (1971) Decree n° 357 de 14/10/1971. Diário Oficial da União, Brasília

(1972) Decree n° 393 de 5/10/1972. Diário Oficial da União, Brasil

(1980) Decree n° 005 de 24/4/1980. Diário Oficial da União, Brasília

(1985) Decree n° 329 de 2/9/1985. Diário Oficial da União, Brasília

Ministério Da Saúde (1985) Decree n° 10 de 8/3/1985, of the Secretaria Nacional de Vigilância Sanitária. Diário Oficial da União, Brasília, March, 1985 (Annex II—Technical monographs of the Ministry of Health on substances with a toxic action on animals or plants whose use is permitted in Brazil for agriculture and animal husbandry, and on Home Sanitary Products)

Olszyna-Marzys AE, Campos M, Farvar MT, Thomas M (1973)

Residuos de plaguicidas clorados en la leche humana en Guatemala. Bol Oficina Sanitaria Panam 74:93–107

Stacey CI, Perriman WS, Whitney S (1985) Organochlorine pesticide residue levels in human milk: Western Australia, 1979–1980. Arch Environ Health 40:102–108

Stacey CI, Tatum T (1985) House treatment with organochlorine pesticides and their levels in human milk—Perth, Western Australia. Bull Environ Contam Toxicol 35:202–208

Strassman SC, Kutz FW (1977) Insecticide residues in human milk from Arkansas and Mississippi, 1973–74. Pest Monit J 10:130–133

Takahashi W, Saidin D, Takei G, Wong L (1981) Organochlorine pesticide residues in human milk in Hawaii, 1979–80. Bull Environ Contam Toxicol 27:506–511

Tanabe H (1972) Contamination of milk with chlorinated hydrocarbon pesticides. In: Matsumura F, Boush GM, Misato T (eds) Environmental toxicology of pesticides. Academic Press, NY pp 239–256

Tuinstra LGM (1971) Organochlorine insecticide residues in human milk in the Leiden region. Netherlands Milk Dairy J 25:24–32

WHO (1986) Principles of evaluating health risks from chemicals during infancy and early childhood: The need for a special approach, World Health Organization, Geneva, (Environmental Health Criteria 59), 73 pp

Yamaguishi T, Fujimoto T, Takeda K, Yoshioka M, Haruda S (1972) Organochlorine pesticide residues in maternal milk and fetal feces. Japanese J Clin Nutr 40:929–934 (Japanese)

Yamamoto I, Hori Y, Shirara Y, Sato Y, Tankawa Y, Mori K, Kawai Y (1975) Investigation on polychlorine biphenyl and organochlorine pesticide residues in maternal milk (1st part). Report of Hokkaido Institute of Public Health 25:94–100 (Japanese)

Yamamoto I, Sato Y, Nishizawa M (1979) Investigation on polychlorine biphenyls and organochlorine pesticide residues in maternal milk (2nd part). Report of Hokkaido Institute of Public Health 29:69–73 (Japanese)

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