

3. RESULTS

3.1 Organochlorine Residue Analysis

3.1.1 Qualitative Analysis

Table 3.1 lists the retention times (RT) of components in the organochlorine insecticide standard mixture. Under the current operating conditions of the GC system employed with an HP-608 capillary column, the 2 peaks of o,p'-DDT and p,p'-DDD compounds in the standard mixture could not be separated chromatographically (Figure 3.1). Therefore, the peak at retention time of 17.930 minutes is reported as the sum of p,p'-DDD and o,p'-DDT. Figures 3.1 and 3.2 show the typical chromatograms of organochlorine standard mixture and egg sample, respectively.

Table 3.1 Retention times of components in the organochlorine standard mixture

Component	RT(min)	Component	RT(min)
Tetrachlor-m-xylene (ISTD1)	9.074	α -Endosulfan	15.777
HCB	10.215	p,p'-DDE	16.317
α -BHC	10.561	Dieldrin	16.631
Quintozen (ISTD2)	11.163	o,p'-DDD	17.059
γ -BHC	11.510	Endrin	17.678
β -BHC	11.679	p,p'-DDD + o,p'-DDT*	17.930
Heptachlor	12.384	β - Endosulfan	18.192
Isodrin (ISTD3)	14.471	p,p'-DDT	18.808
cis-Heptachlor epoxide	14.760	Endosulfan sulfate	19.491
o,p'-DDE	15.667	PCB No. 209 (ISTD4)	25.136

* Two peaks could not be separated chromatographically in chromatogram.

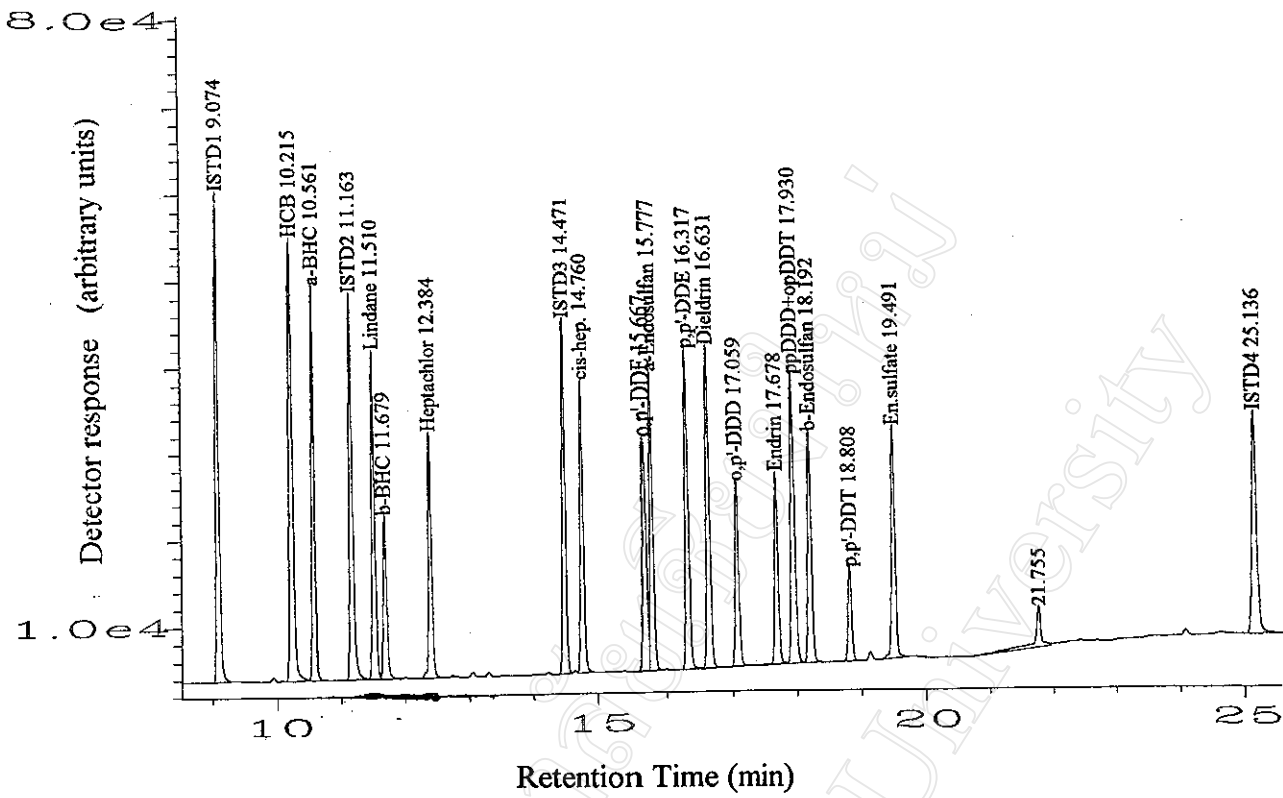


Figure 3.1 Chromatogram of organochlorine standard mixture of 0.1 µg/ml.

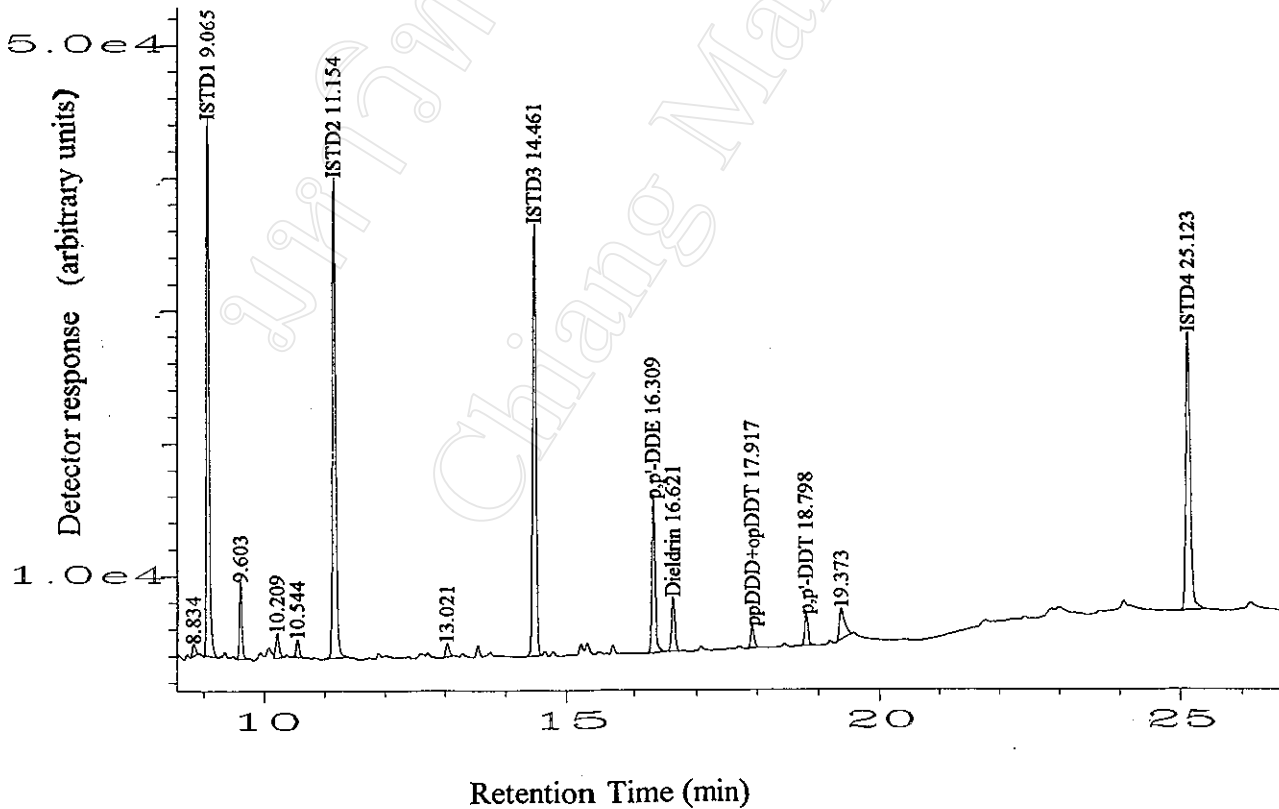


Figure 3.2 Chromatogram of organochlorine residues found in the egg sample (MH3).

3.1.2 Calibration Curves

In order to determine the amount of organochlorine residues in the eggs, the calibration curves were constructed at five concentration levels (0.2, 0.1, 0.05, 0.02, and 0.01 $\mu\text{g/ml}$) for most organochlorine standards, except endosulfan sulfate, the calibration curve was constructed at five concentrations of 0.28, 0.14, 0.07, 0.028, and 0.014 $\mu\text{g/ml}$. A linear regression analysis was done between peak high response and concentration of each organochlorine compound as shown in Table 3.2. The correlation coefficients were relatively good. Figures 3.3 and 3.4 show the calibration curves of some organochlorine pesticides which were mostly found in the egg samples.

Table 3.2 Linear regressions between peak height response and concentration of components in organochlorine standard mixture

Component	Linear regression formula $Y = A + BX^*$	r
ISTD1	$Y = 3337.98 + 253589.80X$	0.994
HCB	$Y = 3547.21 + 236907.71X$	0.995
α -BHC	$Y = 1371.73 + 331535.16X$	0.998
ISTD2	$Y = 2966.57 + 268239.88X$	0.998
γ -BHC (Lindane)	$Y = 1267.79 + 288379.02X$	0.999
β -BHC	$Y = 976.50 + 131956.63X$	0.999
Heptachlor	$Y = 758.20 + 195436.90X$	0.999
ISTD3	$Y = 2407.76 + 278876.78X$	0.997
cis-Heptachlor	$Y = 1641.68 + 243309.45X$	0.999
o,p'-DDE	$Y = 1096.56 + 160897.84X$	0.998
α -Endosulfan	$Y = 1690.67 + 228072.72X$	0.998
p,p'-DDE	$Y = 500.960 + 218721.64X$	0.999
Dieldrin	$Y = 1452.50 + 244698.67X$	0.998
o,p'-DDD	$Y = 1238.38 + 143995.02X$	0.998
Endrin	$Y = -272.85 + 142316.50X$	0.999
o,p'-DDT + p,p'-DDD	$Y = 857.64 + 101510.24X$	0.999
β -Endosulfan	$Y = 1106.53 + 176908.87X$	0.999
p,p'-DDT	$Y = -772.58 + 64278.69X$	0.995
Endosulfan sulfate	$Y = 1249.54 + 112239.28X$	0.998
ISTD 4	$Y = 2047.93 + 159306.14X$	0.998

* Y = peak height response (arbitrary units),

X = concentration of organochlorines ($\mu\text{g/ml}$), r = correlation coefficient

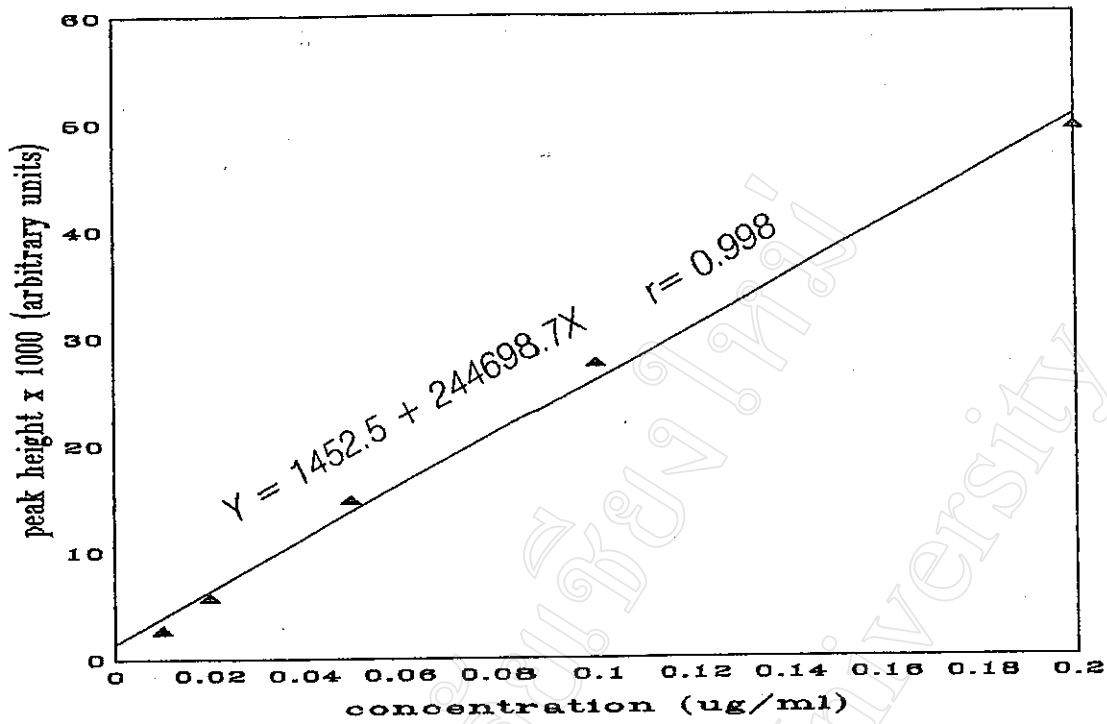


Figure 3.3 Calibration curve of dieldrin.

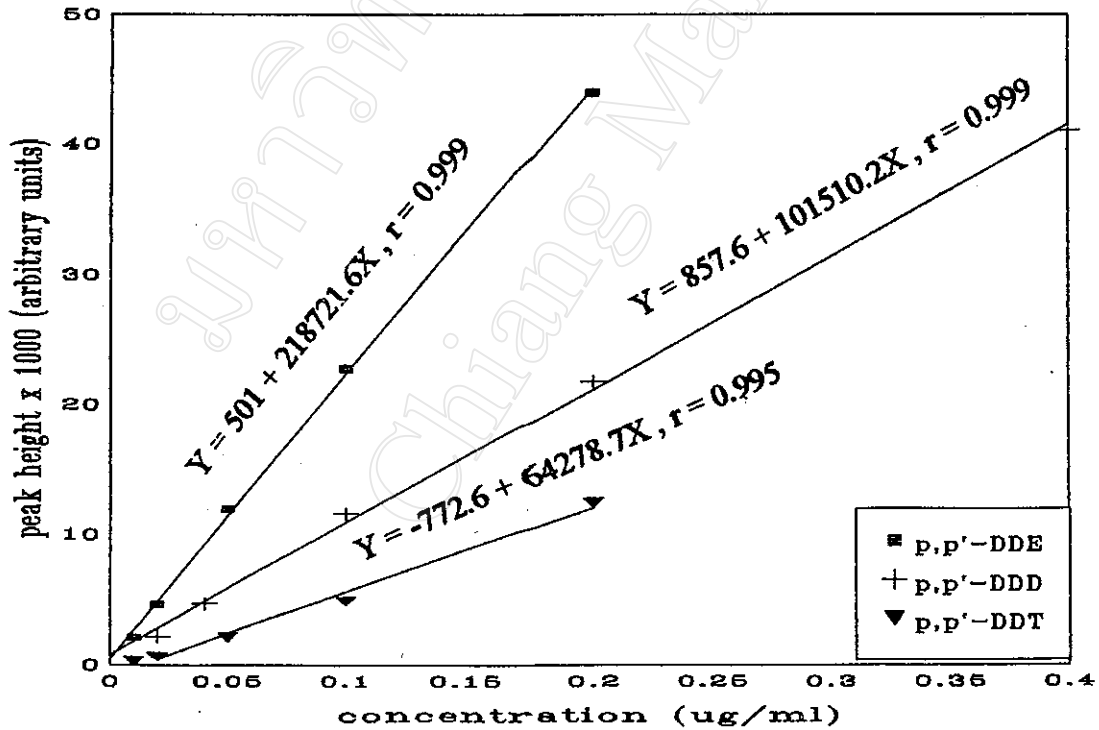


Figure 3.4 Calibration curves of p,p'-DDE, p,p'-DDT, and p,p'-DDD + o,p'-DDT.

3.1.3 Detection Limit and Determination Limit

Figure 3.5 shows the noise signal level, which is approximately 50 arbitrary units, determined from a chromatogram of 0.01 $\mu\text{g/ml}$ organochlorine standard mixture. The detection limit and determination limit estimated based on this noise signal level are presented in Table 3.3. The results shown in Table 3.3 indicate that following the previously mentioned analytical procedure (section 2.4), the detection limit and the lower limit of determination are low enough for risk assessment and for comparison with the MRL of organochlorine residues in eggs which varies from 0.05 to 0.5 mg/kg egg, depending on the type of organochlorine compounds [36].

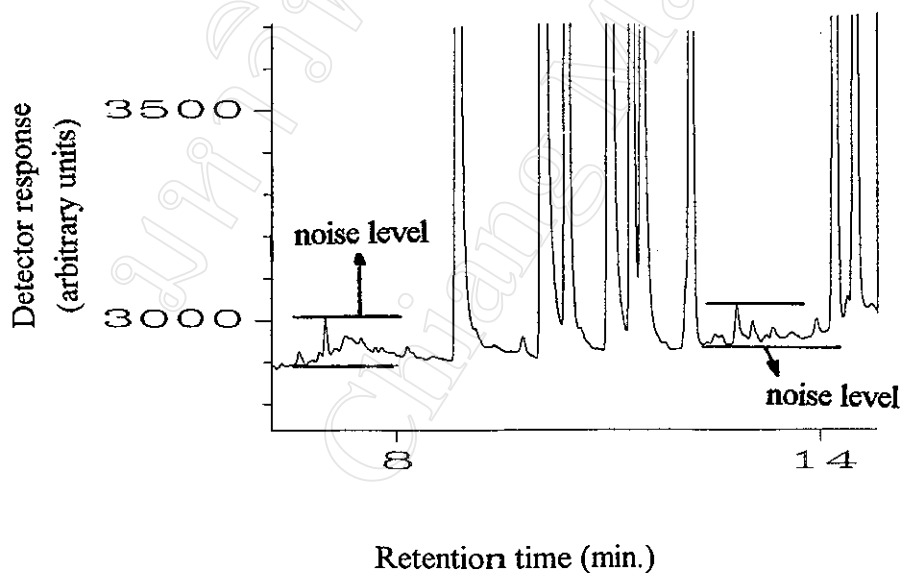


Figure 3.5 Chromatogram showing the noise signal level.

Table 3.3 Detection limit (pg) and determination limit (mg/kg) of some organochlorine compounds

Organochlorine	Amount of component injected (ng)	Peak height	Detection Limit * (pg)	Determination Limit (mg/kg)
HCB	0.01	3813	0.27	0.0001
α -BHC	0.01	3325	0.31	0.0001
γ -BHC	0.01	3104	0.34	0.0001
β -BHC	0.01	1710	0.61	0.0002
Heptachlor	0.01	2367	0.44	0.0001
cis-Heptachlor epoxide	0.01	3016	0.34	0.0001
o,p'-DDE	0.01	1948	0.53	0.0002
α -Endosulfan	0.01	2849	0.37	0.0001
p,p'-DDE	0.01	2185	0.48	0.0002
Dieldrin	0.01	2725	0.38	0.0001
o,p'-DDD	0.01	1933	0.54	0.0002
Endrin	0.01	1246	0.83	0.0003
p,p'-DDD + o,p'-DDT	0.02	2233	0.93	0.0003
β -Endosulfan	0.01	2114	0.49	0.0002
p,p'-DDT	0.01	305	3.41	0.0011
Endosulfan Sulfate	0.01	1999	0.73	0.0002

* Detection limit was calculated following the equation 2.3

3.1.4 Reproducibility and Precision

Reproducibility of the electron-capture detector used in this study was determined by injecting 0.2 $\mu\text{g/ml}$ organochlorine standard mixture 10 times onto GC system under optimum operating conditions. The results shown in Tables 3.4 and 3.5 indicate that the ECD response was adequately reproducible for all of compounds in the organochlorine standard mixture investigated. The ECD response to p,p'-DDT was found to be less reproducible than that of other organochlorines (indicated by the much higher coefficient of variation (6.18) compared with others) (Table 3.5).

Table 3.4 Reproducibility of retention time (minutes) of components in organochlorine standard mixture

Injection No.	ISTD 1	HCB	α -BHC	ISTD2	Lindane	β -BHC	Heptachlor	ISTD3	Cis-heptachlor epoxide	o,p' -DDE	α -Endosulfan	p,p' -DDE	Dieldrin	o,p' -DDD	Endrin	p,p' -DDD	o,p' -DDT	β -Endosulfan	p,p' -DDT	Endosulfan sulfate	ISTD4
1	8.951	10.083	10.431	11.030	11.373	11.526	12.246	14.324	14.614	15.523	15.627	16.172	16.481	16.911	17.528	17.777	18.039	18.039	18.658	19.338	24.952
2	8.969	10.103	10.451	11.051	11.394	11.549	12.268	14.347	14.636	15.545	15.650	16.194	16.504	16.933	17.551	17.801	18.062	18.062	18.679	19.361	24.981
3	8.975	10.110	10.457	11.057	11.401	11.557	12.276	14.355	14.645	15.553	15.659	16.202	16.513	16.942	17.560	17.810	18.072	18.072	18.690	19.371	24.993
4	8.973	10.107	10.455	11.055	11.399	11.554	12.272	14.352	14.642	15.550	15.656	16.199	16.509	16.940	17.556	17.807	18.069	18.069	18.686	19.368	24.989
5	8.971	10.105	10.453	11.052	11.397	11.551	12.270	14.350	14.639	15.548	15.652	16.196	16.506	16.936	17.554	17.804	18.065	18.065	18.682	19.363	24.984
6	8.978	10.113	10.462	11.061	11.405	11.561	12.279	14.359	14.649	15.557	15.663	16.206	16.516	16.945	17.563	17.814	18.076	18.076	18.693	19.374	24.999
7	8.904	10.032	10.380	10.977	11.318	11.471	12.189	14.262	14.552	15.461	15.563	16.109	16.416	16.848	17.461	17.715	17.972	17.972	18.592	19.271	24.866
8	8.955	10.088	10.434	11.033	11.377	11.529	12.249	14.327	14.617	15.525	15.629	16.173	16.482	16.912	17.529	17.780	18.040	18.040	18.658	19.339	24.951
9	8.949	10.081	10.428	11.027	11.369	11.522	12.242	14.320	14.609	15.517	15.621	16.166	16.474	16.905	17.521	17.771	18.031	18.031	18.649	19.331	24.938
10	8.962	10.096	10.443	11.043	11.386	11.540	12.259	14.338	14.628	15.537	15.641	16.185	16.495	16.925	17.542	17.792	18.054	18.054	18.672	19.353	24.973
Mean	8.96	10.09	10.44	11.04	11.38	11.54	12.26	14.33	14.62	15.53	15.64	16.18	16.49	16.92	17.54	17.79	18.05	18.05	18.67	19.35	24.96
SD	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04
%CV	0.24	0.20	0.19	0.22	0.16	0.26	0.24	0.18	0.20	0.19	0.19	0.19	0.18	0.26	0.17	0.17	0.17	0.17	0.16	0.16	0.21

Table 3.5 Reproducibility of ECD responses as peak height in arbitrary units of components in organochlorine standard mixture

Inject- ion No.	ISTD1	HCB	α -BHC	ISTD2	Lindane	β - BHC	Hepta- chlor	ISTD3	cis- hepta- chlor epoxide	o,p'- DDE	α - Endo- sulfan	p,p'- DDE	Diel- drin	o,p'- DDD	Endrin	p,p'- DDD o,p'- DDT	β - Endo- sulfan	p,p'- DDT	Endo- sulfan sulfate	ISTD 4
1	92491	82759	98796	81099	79806	37742	52126	81837	66583	47551	65698	65169	72090	42032	38076	58112	51353	14717	46093	47417
2	92558	84268	97103	80688	79008	37513	52597	80893	64932	47382	63828	64961	71235	40192	37990	57166	50408	15982	45215	46489
3	92987	84243	96290	79991	78273	37731	52040	80061	64715	46635	64203	65302	70337	40299	37663	56885	49999	16342	45061	47062
4	93779	84030	97225	80458	79707	37497	51934	80958	64875	47578	64253	64879	70790	41089	38303	57486	50976	16708	45850	47287
5	93115	83245	97418	80562	78293	36851	51012	80528	64239	46594	63176	62821	69755	40100	35831	55822	49193	14607	43611	45364
6	93009	83499	96737	80022	78185	37217	51414	79890	64544	46907	64331	65811	69845	40428	37697	57874	50033	15900	45787	47434
7	94595	84756	101301	83223	82722	38168	54228	83960	67934	48674	67737	66588	73397	41669	39150	58258	52156	16550	46920	48359
8	94793	84515	100064	81390	81281	38679	54081	83164	66996	48910	67390	67047	73842	42167	40222	60424	52924	17720	48436	49744
9	94302	84523	101217	83030	81676	38267	53415	83473	67471	48560	66992	66694	72288	42121	38402	58716	51925	16023	47237	47898
10	94551	83963	99276	81864	80497	38060	51863	82107	65411	47788	65643	66273	72020	41609	37563	58357	51345	14861	45970	47126
Mean	93618	83980	98543	81233	799448	37773	52471	81687	65770	47658	65325	65555	71560	41171	38090	57910	51031	15941	46018	47418
SD	889.1	632.5	1858.5	1154.1	1576.7	538.4	1095.2	1457.4	1347.1	834.5	1611.0	1232.4	1414.1	849.9	1132.3	1223.7	1139.3	985.40	1316.1	1147.0
%CV	0.95	0.75	1.89	1.42	1.97	1.43	2.09	1.78	2.05	1.75	2.47	1.88	1.98	2.06	2.97	2.11	2.23	6.18	2.86	2.42

3.1.5 Percentage Recovery

To determine the percentage recovery, 100 ng of each surrogate was spiked to all egg samples. The average percent recovery from 79 eggs analyzed was 99.7% \pm 7.7% (mean \pm SD) which varied between 85%-117% (see detailed data in Appendix Tables 9 and 10). Ninety percent of egg samples have recoveries varying from 90% to 110%, i.e. only 10% of the samples were out of this range, but they still were above the acceptable percent recovery of 70%-80% for any pesticide residue analysis [43].

3.1.6. Intra-laboratory Quality Control

For quality assurance, 15 egg samples were sent to Germany for repeating another organochlorine residue analysis. The comparison of organochlorine analysis results in these egg samples conducted at Chiang Mai University, Thailand with those done at University of Saarland, Biogeography Institute, Germany is shown in Table 3.6. It was found that there were no significant differences between the Thai and German results for all organochlorine residue levels detected ($p > 0.9$, as shown in Appendix 2.1). The eggs contained the highest concentration of total DDT residue found in Mae Rim District (sample MRN2) and in Muang District (sample HCK1) were also sent to be confirmed in Germany. The results are shown in Table 3.6.

Table 3.6 Comparison of organochlorine residue analyses in hens' eggs conducted in Thailand and Germany (at 100% of recovery)

Sample Code	Analysis results at Chiang Mai University, Thailand								Analysis results at University of Saarland, Germany						
	Organochlorines (mg/kg fresh weight)								Organochlorines (mg/kg fresh weight)						
	Cis-Hep*	Diel-drin	o,p'-DDE	p,p'-DDE	o,p'-DDD	p,p'-DDD**	p,p'-DDT	DDT-total	Diel-drin	o,p'-DDE	p,p'-DDE	p,p'-DDD	o,p'-DDT	p,p'-DDT	DDT-total
MA1	.007	.030	.007	.024	.000	.000	.017	.048	.030	.000	.033	.013	.000	.009	.055
MA2	.007	.037	.006	.016	.000	.000	.034	.056	.038	.000	.020	.014	.000	.006	.040
MA3	.008	.033	.004	.013	.000	.000	.010	.027	.036	.000	.018	.011	.006	.004	.039
MA4	.008	.032	.000	.013	.000	.000	.009	.022	.039	.000	.022	.011	.000	.003	.036
MA6	.010	.041	.004	.016	.000	.000	.010	.030	.039	.000	.022	.014	.000	.003	.039
MA7	.009	.041	.004	.013	.000	.000	.011	.028	.045	.000	.021	.011	.000	.004	.036
MA10	.013	.048	.022	.016	.000	.026	.028	.092	.048	.017	.022	.015	.017	.019	.090
SKP3	.000	.003	.000	.020	.000	.005	.014	.039	.005	.000	.025	.000	.005	.008	.038
MH3	.001	.007	.002	.021	.000	.006	.015	.044	.000	.000	.026	.000	.000	.020	.046
HQ1	.001	.090	.003	.010	.000	.002	.007	.022	.100	.000	.015	.000	.000	.007	.022
DK3	.000	.000	.006	.017	.004	.000	.000	.027	.000	.000	.016	.000	.000	.005	.021
DK2	.000	.002	.004	.032	.004	.000	.000	.040	.002	.000	.032	.000	.000	.009	.041
HCK1	.000	.000	.002	.238	.000	.012	.034	.286	.025	.000	.195	.000	.000	.025	.220
HCK2	.000	.002	.001	.526	.000	.032	.057	.616	.000	.000	.390	.000	.000	.060	.450
MRN2	.000	.000	.000	10.6	.005	.318	7.78	18.7	.000	.000	15.5	.000	.000	4.00	19.5

Limit of determination: 0.001 mg/kg for all organochlorine compounds

* : cis-Heptachlor epoxide was not included in the analysis scheme at University of Saarland, Germany.

** sum of p,p'-DDD and o,p'-DDT

3.2 Monitoring of Organochlorine Residues in Eggs from Free-Range

Hens in Chiang Mai Suburban Areas

3.2.1 Organochlorine Residues in Hens' Eggs from One Sampling Site

The variations of organochlorine residues in a clutch of eggs from one hen and from different hens at the same house are displayed in Figure 3.6 whereas more detailed data are presented in Appendix Table 9. Table 3.7 summaries the range of organochlorine residues found in the eggs from different free-range hens at the same house and at different houses in one sampling site.

Table 3.7 Organochlorine residues in eggs (mg/kg) from one hen and from different hens at the same house and at three different houses in one sampling site.

Source of eggs	No. of eggs	Total DDT Mean \pm SD (range)	Dieldrin Mean \pm SD (range)	Heptachlor epoxide Mean \pm SD (range)
At the same house				
1-year old hen	10	0.047 \pm 0.024 a* (0.022-0.099)	0.040 \pm 0.007 a (0.030-0.051)	0.009 \pm 0.002 a (0.007-0.014)
2-year old hen	3	0.037 \pm 0.016 a (0.019-0.046)	0.017 \pm 0.002 b (0.015-0.019)	0.004 \pm 0.001 b (0.004-0.005)
3-year old hen	2	0.106 \pm 0.004 b (0.109-0.102)	0.052 \pm 0.001 a (0.051-0.052)	0.013 \pm 0.000 c (0.013-0.013)
At 3 different houses	3**	0.043 \pm 0.027 (0.013-0.050)	0.018 \pm 0.018 (0.002-0.038)	0.000

Limit of determination: 0.001mg/kg for all of organochlorines

* Results of statistical analysis (see Appendix 2.2)

** Three eggs (coded as M1, M2, and M3) were collected from 3 hens which were the same age and variety at one sampling site

In a clutch of eggs from 1-year old hen the residues of cis-heptachlor epoxide and dieldrin increased at the end of egg laying. The residues of DDT and its derivatives varied more than other organochlorines, but total DDT residues also increased at the end of egg laying. The organochlorine concentration in a clutch of eggs of one hen did not vary much, i.e. standard deviation (SD) was small, e.g. for total DDT residues, SD=0.024, dieldrin, SD=0.007, and for cis-heptachlor epoxide, SD=0.002. Thus, using one egg from one hen would be enough to represent the whole clutch of eggs. The mean total DDT and cis-heptachlor epoxide residues in eggs from the 3-year old hen were higher than those found in the eggs from both 1 and 2-year old hens ($p < 0.01$). Dieldrin and cis-heptachlor epoxide residue levels in eggs of the 2-year old hen were less than those of other hens ($p < 0.01$) while there was no significant difference of total DDT residues between the 2-year old hen and the 1-year old hen (Appendix 2.2). It appeared that the age of hen may be one of factors affecting organochlorine accumulation in hens' eggs.

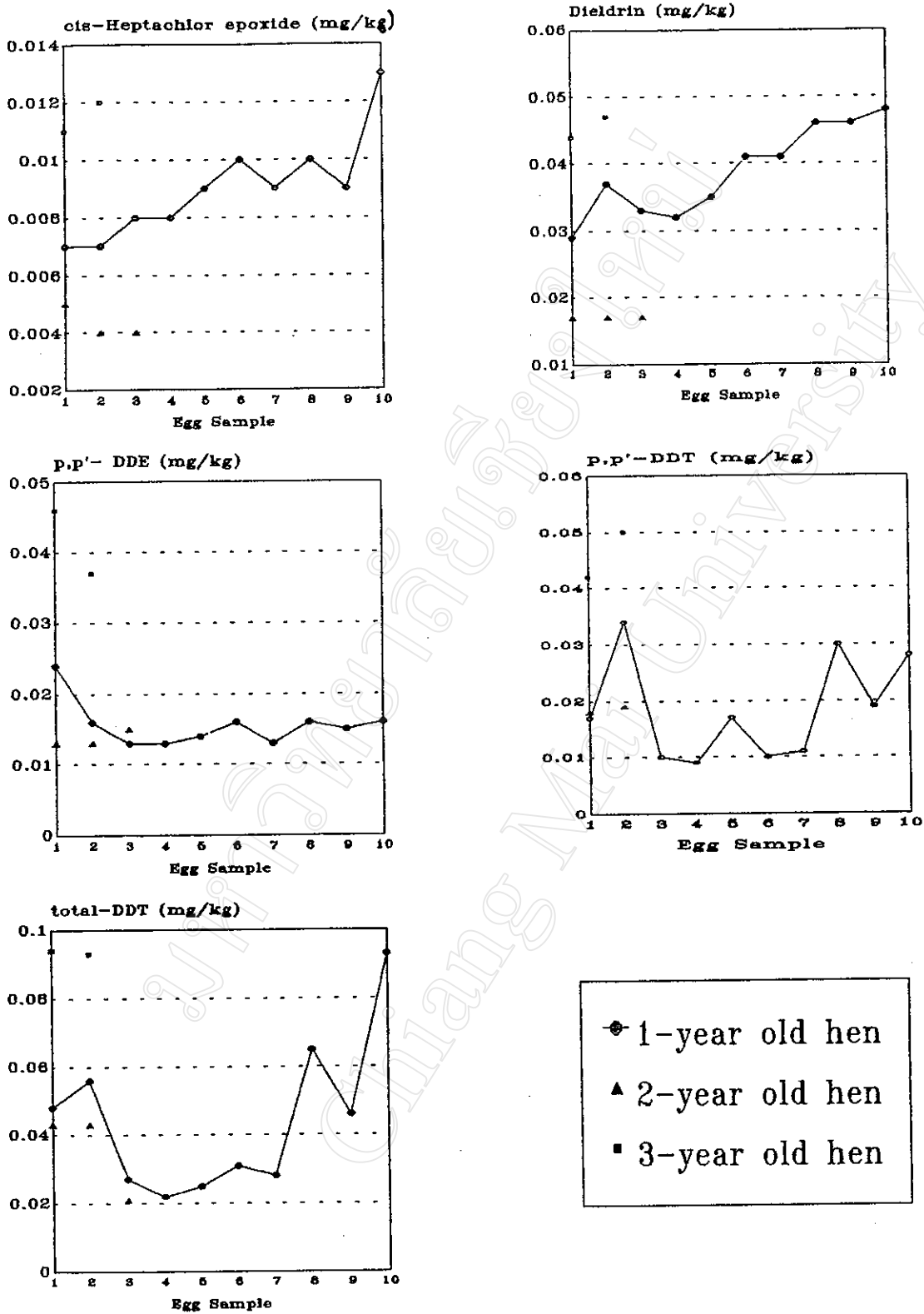


Figure 3.6 Variation of organochlorine residues in a clutch of eggs from one hen and from 3 different hens at one house (100 % of recovery).

3.2.2 Organochlorine Residues in Eggs from Free-Range Hens in Chiang Mai Suburban Areas

3.2.2.1 DDT and Its Derivatives

All eggs analyzed contained residue of the insecticide p,p'-DDE. p,p'-DDT was found in most samples (94% of the eggs analyzed), followed by p,p'-DDD and o,p'-DDT (88%), o,p'-DDE (77%), and o,p'-DDD (19%). Table 3.8 summarizes the mean concentration of total DDT and the p,p'-DDT to p,p'-DDE ratios in the eggs from the study areas. It can be seen from Table 3.8 that the mean concentration of total DDT in eggs from Muang and San Kampaeng Districts were below the ERL [36] while the corresponding values for Mae Rim and Hang Dong Districts were higher than this limit, or even exceeding the MRL of Thailand which is already 3 times higher than the ERL. The mean values of total DDT found in eggs from Mae Rim and Hang Dong Districts were significantly higher than those from Muang and San Kampaeng Districts ($p < 0.001$). The statistical analysis results are presented in Appendix 2.3. The mean ratio of p,p'-DDT to p,p'-DDE found in Mae Rim was the highest, followed by that in Muang, Hang Dong and San Kampaeng (Table 3.8). This high ratio was also found in the study areas where DDT is still in use ($p < 0.01$) (Appendix 2.4). Total DDT, p,p'-DDT, p,p'-DDE, and p,p'-DDD residues in the eggs from DDT-sprayed areas were significantly higher than those from formerly DDT-sprayed areas ($p < 0.0001$) (Appendix 2.4). These findings were also found in Mae Rim and Hang Dong Districts. When the eggs were grouped according to areas or land-use type, the highest mean and individual values of total DDT were found in eggs from forestry and mountainous areas. The levels were lower in high density residential areas ($p < 0.001$) (Appendix 2.5).

Table 3.8 Total DDT residues and p,p'-DDT to p,p'-DDE ratios in eggs from free-range hens in Mae Rim, Hang Dong , Muang and San Kampaeng Districts

District	No. of eggs			Total DDT (mg/kg egg)	ratio p,p'-DDT p,p'-DDE			
	Total	Positive	≥ ERL	Mean ± SD (range) median	Mean ± SD (range) median	%> 1.00		
Mae Rim	21	21	14	3.06 ¹² ± 4.64 (0.030-18.7) 1.87	a	1.7 ± 1.1 (0.-4.7) 1.2	a	62
Hang Dong	19	19	10	1.96 ¹² ± 2.44 (0.020-7.68) 0.540	a	1.0 ± 0.93 (0.06-3.9) 0.77	a	37
Muang	15	15	1	0.07 ¹ ± 0.14 (0.012-0.553) 0.028	b	1.1 ± 0.86 (0.11-2.7) 0.58	a	47
San Kampaeng	9	9	0	0.02 ± 0.01 (0.004-0.035) 0.015	b	0.59 ± 0.19 (0.29-0.88) 0.50	b	0

Limit of determination :0.001 mg/kg for all organochlorine compounds

¹ Mean ≥ ERL of WHO [36], ² Mean ≥ MRL of Thailand [61]

3.2.2.2 Cyclodiene Group

1). Dieldrin and Endrin

Endrin was not found in any of the eggs analyzed while dieldrin was found in 50% of the eggs with no egg exceeding the codex maximum residue limit of 0.1 mg/kg egg [36] (Table 3.9). Dieldrin was more frequently detected in the craft-industrial area (San Kampaeng) and residential area (Muang) than in the agricultural and mountainous areas (Hang Dong and Mae Rim). The statistical results found that there were no significant differences in the levels of dieldrin residue distributed among these areas.

2). Heptachlor and cis-Heptachlor epoxide

No heptachlor was detected in the eggs while in 23% of the eggs heptachlor epoxide residue was found. Like dieldrin, none of the eggs exceeded the codex maximum residue limit which is 0.05 mg heptachlor kg^{-1} egg [36]. The number of positive eggs (i.e. the number of eggs which contain more than 0.001 mg of cis-heptachlor epoxide kg^{-1} egg) found in Mae Rim and Hang Dong was higher than in Muang District, but the mean levels of cis-heptachlor epoxide residue were all the same among the study areas (Table 3.9).

3). Endosulfan Group

There are no residues of α -endosulfan, β -endosulfan, and endosulfan sulfate in the surveyed eggs with the determination limit of 0.001 mg/kg.

Table 3.9 Dieldrin and cis-heptachlor epoxide residues (mg/kg) in eggs from free-range hens in Mae Rim, Hang Dong, Muang and San Kampaeng Districts

District	No. of eggs	Dieldrin			cis-heptachlor epoxide		
		No. positive	No. \geq ERL	Mean \pm SD (range)	No. positive	No. \geq ERL	Mean \pm SD (range)
Mae Rim	21	7	0	0.002 \pm 0.005 (0-0.019)	7	0	0.001 \pm 0.001 (0-0.004)
Hang Dong	19	9	0	0.004 \pm 0.007 (0-0.029)	6	0	0.0005 \pm 0.0008 (0-0.002)
Muang	15	10	0	0.013 \pm 0.025 (0-0.092)	2	0	0.0001 \pm 0.0003 (0-0.001)
San Kampaeng	9	6	0	0.006 \pm 0.013 (0-0.040)	0	0	0

Determination limit: 0.001 mg dieldrin or cis-heptachlor epoxide kg^{-1} egg
 Extraneous residue limit (ERL): 0.1 mg dieldrin or 0.05 heptachlor kg^{-1} egg [36]

3.2.2.3. Hexachlorohexane (BHC group) and Hexachlorobenzen (HCB)

Neither pesticides of the BHC group nor HCB were detected in any eggs with the limit of determination of 0.001 mg of BHC group or HCB kg⁻¹ egg.

3.2.2.4 Summary of Results

The results of surveying the organochlorine residues in eggs from free-range hens in some Chiang Mai suburban areas are clearly demonstrated in Figure 3.7. Among egg samples from the four districts, Mae Rim eggs were found to be more contaminated with DDT and its derivatives than those from other districts surveyed. Figures 3.8 and 3.9 are the chromatograms of egg samples with highest concentrations of total DDT residues in Mae Rim and Hang Dong Districts, respectively. The highest concentration of total DDT found in Chiang Mai suburban areas (sample MRN2) was confirmed by repeating organochlorine analysis with the same egg, and with extra egg collected from the same site and by intra-laboratory testing (Table 3.6).

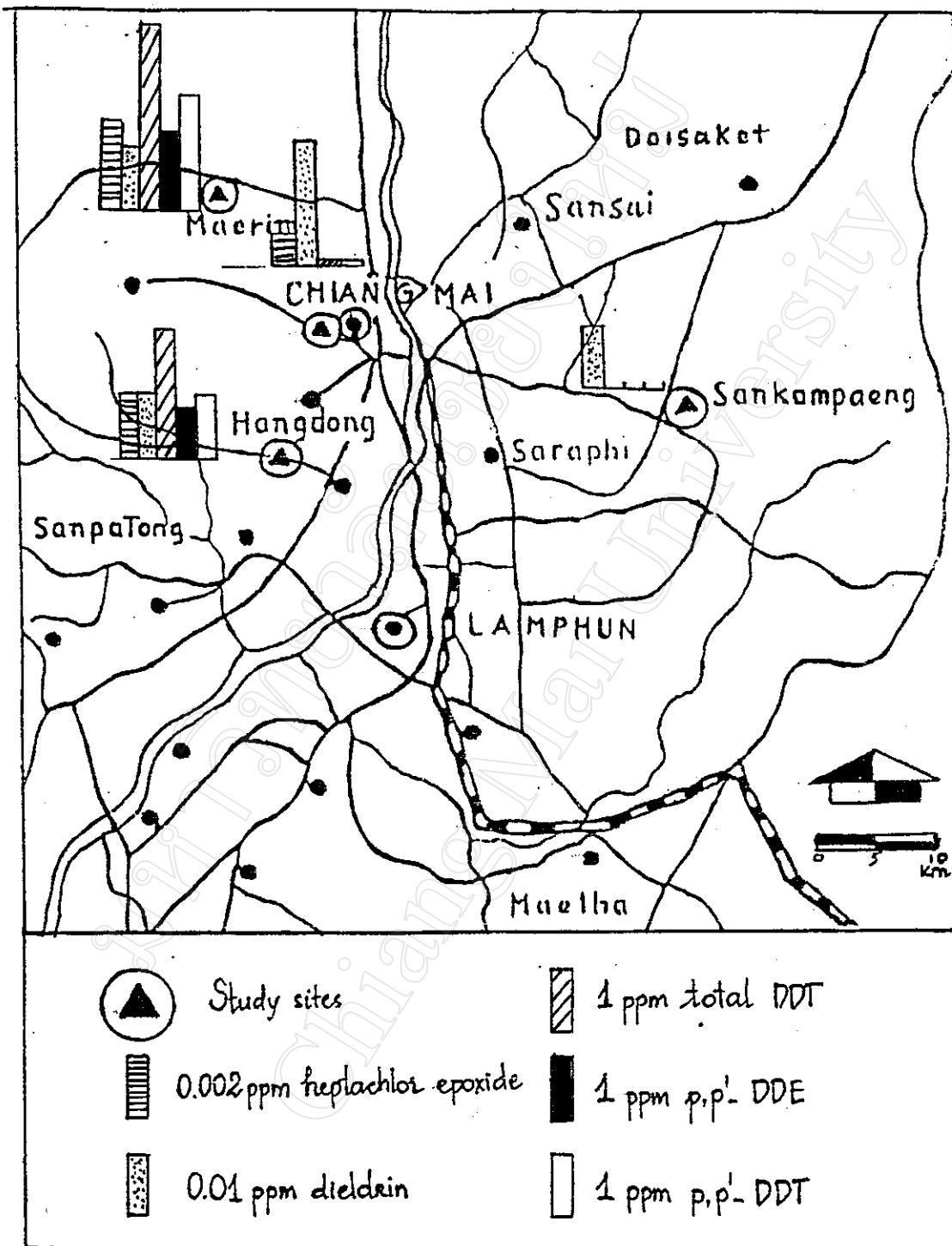


Figure 3.7 Map showing levels of organochlorine residues in eggs in the study areas.

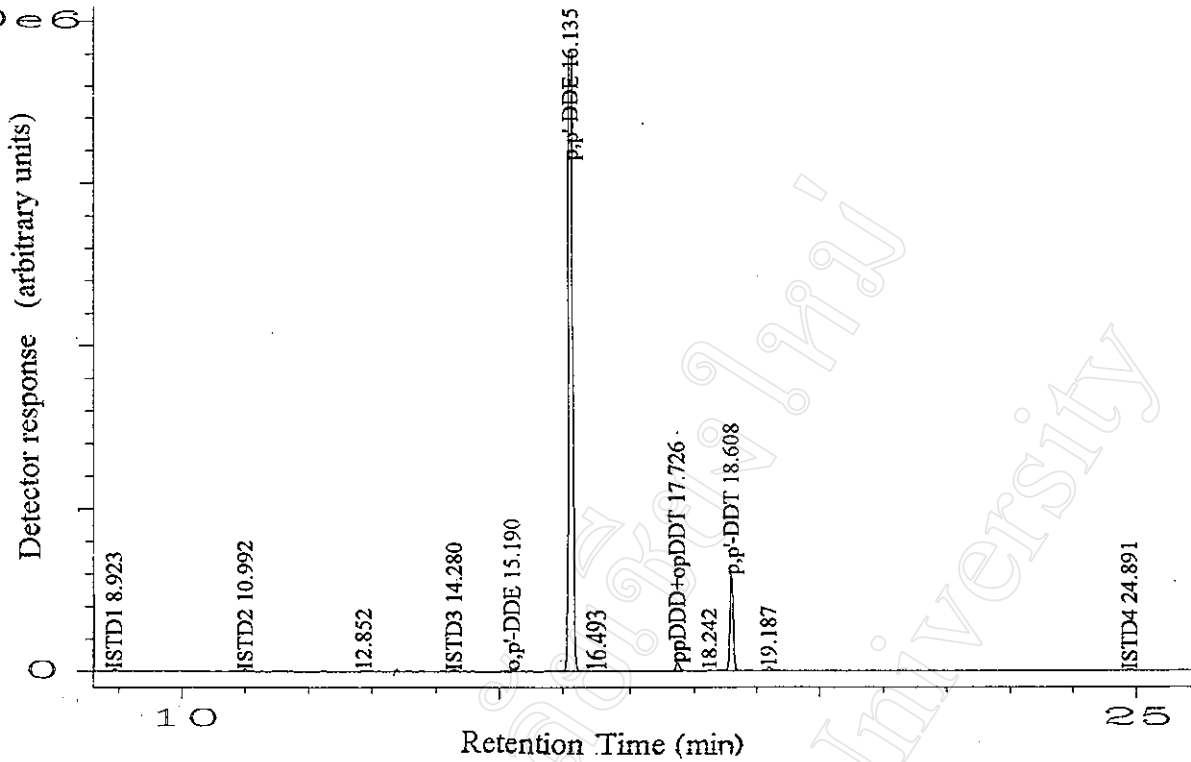


Figure 3.8 Chromatogram showing the highest concentration of total-DDT found in the egg from Mae Rim District (MRN 2).

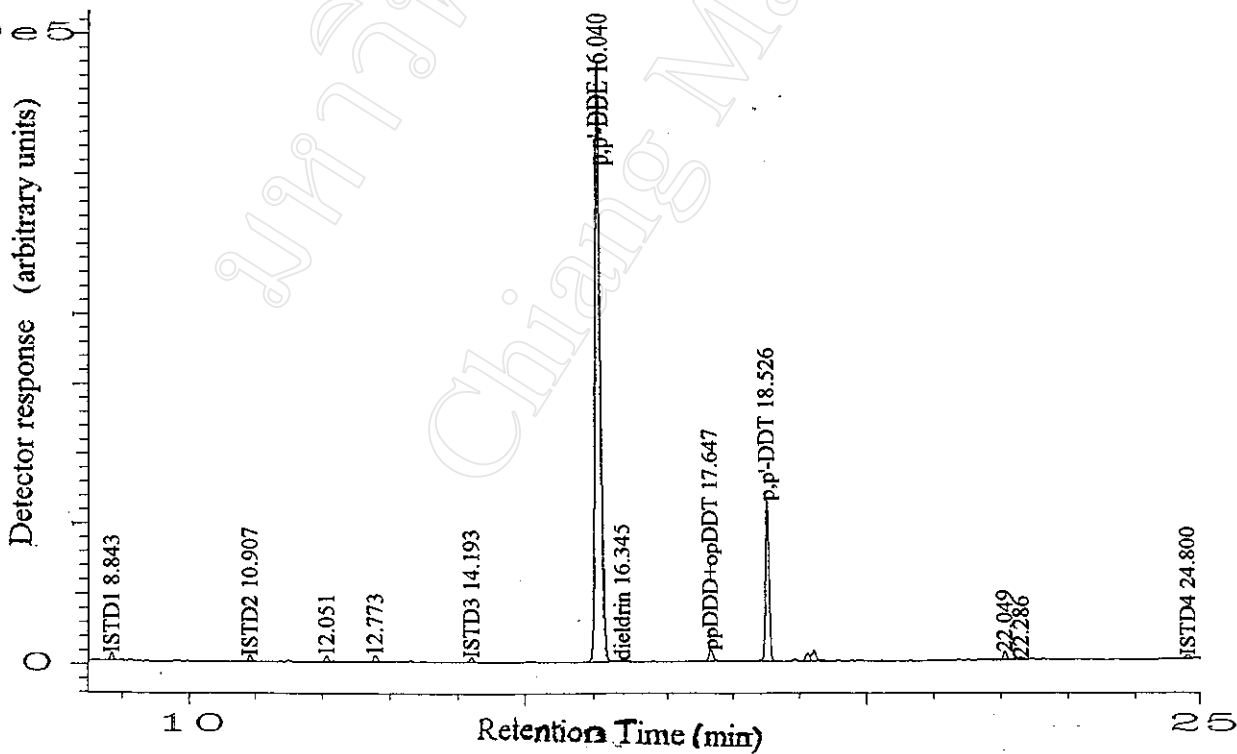


Figure 3.9 Chromatogram showing the highest concentration of total-DDT found in the egg from Hang Dong District (H51).

3.2.3. Correlation Among Organochlorine Residues and Between Organochlorine Residues and the Egg Weight

In this study, the correlations between the egg weight and the concentrations of organochlorine compounds detected were all negative (Appendix 2.6). The negative effects of total DDT and p,p'-DDE on the egg weight were significant ($p < 0.05$, $n = 77$). No significant relationship between the fat contents of eggs and the concentrations of organochlorine residues was found. The residues of p,p'-DDE and p,p'-DDD were strongly correlated with p,p'-DDT ($n = 79$, $p < 0.001$, $r > 0.86$) (Appendix 2.6). A multiple regression analysis was done among the variables p,p'-DDT, p,p'-DDE, and p,p'-DDD. The equations derived from this statistical analysis for both formerly DDT-sprayed areas and DDT-sprayed areas are shown in Appendix 2.7