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Correlation Between Total DDT Residues in Blood and Fat of Beef Animals[1]

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ABSTRACT

In Guatemala, where in certain regions heavily pesticide-sprayed cotton fields are interspersed with pastures for cattle, pesticide residues in beef fat represent a problem. Organochlorine pesticides are still widely used and even if the use of DDT has been decreasing over the last few years, this pesticide is still a major food contaminant. The present study was undertaken to establish if a correlation between total DDT levels in blood and fat could be found. Samples of blood and fat from 30 bovines were analyzed by gas-liquid chromatography. The "ppm in fat/ppb in blood" ratio was calculated to be 0.96 ± 0.39 (mean ± S.D.), the regression line to be $Y = 2.54 + 0.61\ X$ (Y = ppb in blood, X = ppm in fat) and the correlation coefficient to be 0.889. It was established that blood analysis may be used to estimate, before slaughter, if the residue levels in the fat are exceeding the legal limits.

In the Pacific coastal plains of Guatemala, extensive and heavily pesticide-sprayed cotton fields are interspersed with pastures for milk and beef cattle. Organochlorine pesticides are still widely used, and even if the use of DDT is decreasing because of the new pesticide law (*3*), this pesticide is still a major food contaminant. The toxic effects of organochlorines have been reported to be higher in subjects on deficient diets (*7*), an important fact in Guatemala where protein-calorie malnutrition is very high (*9*).

At present, kidney fat collected after slaughter is used for determination of pesticide residues. When high levels are found, some decision must be made on the disposition of the carcass. Rejection of the meat represents a high economic loss and, if released, it represents a potential health hazard. Estimation of the residue levels before slaughter would prevent killing highly contaminated animals. Ware et al. (*10*) investigated the correlation between total DDT in blood and kidney fat. They concluded that analysis of blood samples may be used to estimate total DDT in carcass fat before slaughter.

The present study was undertaken to establish if the same correlation would be found under local conditions in Guatemala. In developing countries, data from other countries are too often used without further confirmation. It should be taken into account, however, that local conditions may change the results and the conclusions.

[1] *Thesis work by C. E. Gutiérrez B. in obtaining the Veterinary Surgeon degree.*
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MATERIALS AND METHODS

Samples

Samples of blood and fat were collected from 30 bovines of different sex and breed in the Department of Escuintla on the Pacific Coast. Twenty ml of blood were taken by puncture of the jugular vein and collected in glass tubes containing 4 drops of heparin as an anticoagulant. The tubes, as well as all the glassware used for analysis, were previously washed with soap and water, rinsed with tap water and distilled water, dried and then rinsed with Nanograde® acetone and petroleum ether. About 1 g of fat was obtained by biopsy in the sternum region and wrapped in aluminum foil. A previous study in this laboratory showed the residue levels in kidney fat to be equal to those in the pectoral region ($r = 0.984$, $p < 0.05$) (*8*). The blood samples were kept at 4 C for a few days before they were analyzed, the fat samples at -20 C for a few weeks (*4,5*).

Analysis

The fat was rendered and filtered at 130 C and 0.25 g was analyzed as described by McLeod and Ritcey (*5*). The samples were analyzed in duplicate; the mean coefficient of variation was 10%. The mean recovery of known added quantities of DDT and its metabolites (o,p′ - and p,p′ - isomers of DDT, DDE and DDD) carried through the whole method was 80%. The results are reported in ppm (parts per million). The blood samples were analyzed as described by Brown and Chow (*1*). The mean coefficient of variation between duplicates was 8% and the mean recovery 75%. Heparin gave no interference peaks. The blood values are reported in ppb (parts per billion). The extracts were analyzed by gas-liquid chromatography (GLC) as follows: gas chromatograph: TRACOR, Model MT-220; columns: 6 ft, ¼inch OD; off-column injection, 200 C; column for identification and quantification: 1.5% OV17/1.95% QF1; column for confirmation: 4% SE30/6% QF1; injection port: 225 C; transfer line: 257 C; and detector Ni^{63}: 275 C.

RESULTS AND DISCUSSION

The results are tabulated in columns A and B of Table 1. A roughly 1000-fold ratio can be found between the two values (Column D), meaning that the ppm value in fat is roughly equal to the ppb value in blood. The relation: ppm in fat/ppb in blood was calculated as 0.96 ± 0.39 (mean ± S.D.). The same data are illustrated in Fig. 1 with the fat values in the abscissa (X) and the blood values in the ordinate (Y). The linear regression line was calculated as $Y = 2.54 \pm 0.61X$ or $X = \frac{Y - 2.54}{0.61}$ and the correlation coefficient as $r = 0.889$.

The values calculated by this procedure (ppm in fat = $\frac{\text{ppb in blood} - 2.54}{0.61}$ are reported in Column C (Table 1), and the relation between real and estimated values is illustrated in Fig. 2.

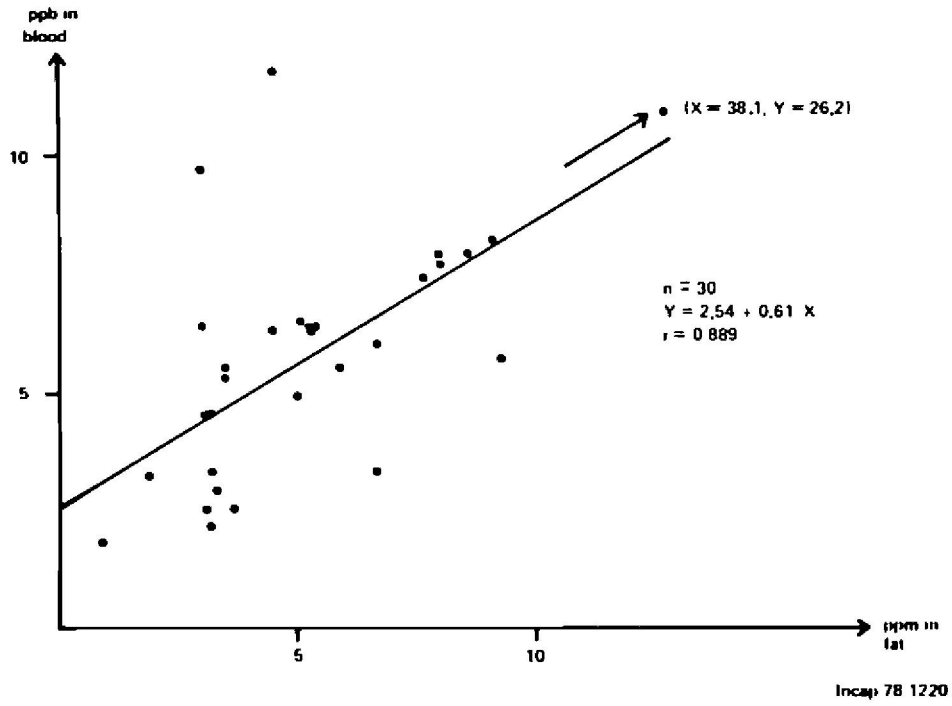

Figure 1. *Correlation between total DDT levels in blood and fat of bovines.*

TABLE 1. *Total DDT residues in blood and fat of bovines.*

No.	A Blood (ppb)	B Fat (ppm), real value	C Fat (ppm), calculated value[a]	D Ratio ppm in fat / ppb in blood
1	11.80	4.51	15.20	0.38
2	4.47	3.16	3.16	0.71
3	6.35	5.44	6.25	0.86
4	5.46	5.92	4.79	1.10
5	4.90	4.97	3.87	1.00
6	1.76	0.87	0.00	0.49
7	5.25	3.45	4.43	0.66
8	6.28	5.26	6.13	0.84
9	2.54	3.69	0.00	1.50
10	6.42	3.03	6.36	0.47
11	5.95	6.73	5.59	1.10
12	2.06	3.20	0.00	1.60
13	3.28	3.17	1.21	0.97
14	6.28	5.29	6.13	0.84
15	2.93	3.26	0.64	1.10
16	2.54	3.11	0.00	1.20
17	8.24	9.14	9.34	1.10
18	7.89	8.02	8.77	1.00
19	4.47	3.05	3.16	0.68
20	5.54	3.46	4.92	0.63
21	6.54	5.11	6.56	0.78
22	7.74	8.02	8.52	1.00
23	26.20	38.10	38.80	1.50
24	3.21	1.90	1.10	0.59
25	3.37	6.74	1.36	2.00
26	7.39	7.71	7.95	1.00
27	9.68	2.96	11.70	0.31
28	6.30	4.52	6.16	0.72
29	5.72	9.31	5.21	1.60
30	7.85	8.62	8.70	1.10
				$\bar{x} = 0.96 \pm 0.39$ (mean ± S.D.)

[a] $\text{ppm in fat} = \dfrac{\text{ppb in blood} - 2.54}{0.61}$

The same regression line calculated from the data of Ware et al. (*10*) is $Y = 0.27 + 1.1X$, the line having a much steeper slope and passing almost through zero (for calculation purposes 0.9 was used where < 1 ppb was reported). The reason for this difference is not clear. Breed or sex of the animals, chronicity of the contamination or climatic conditions may be contributing factors.

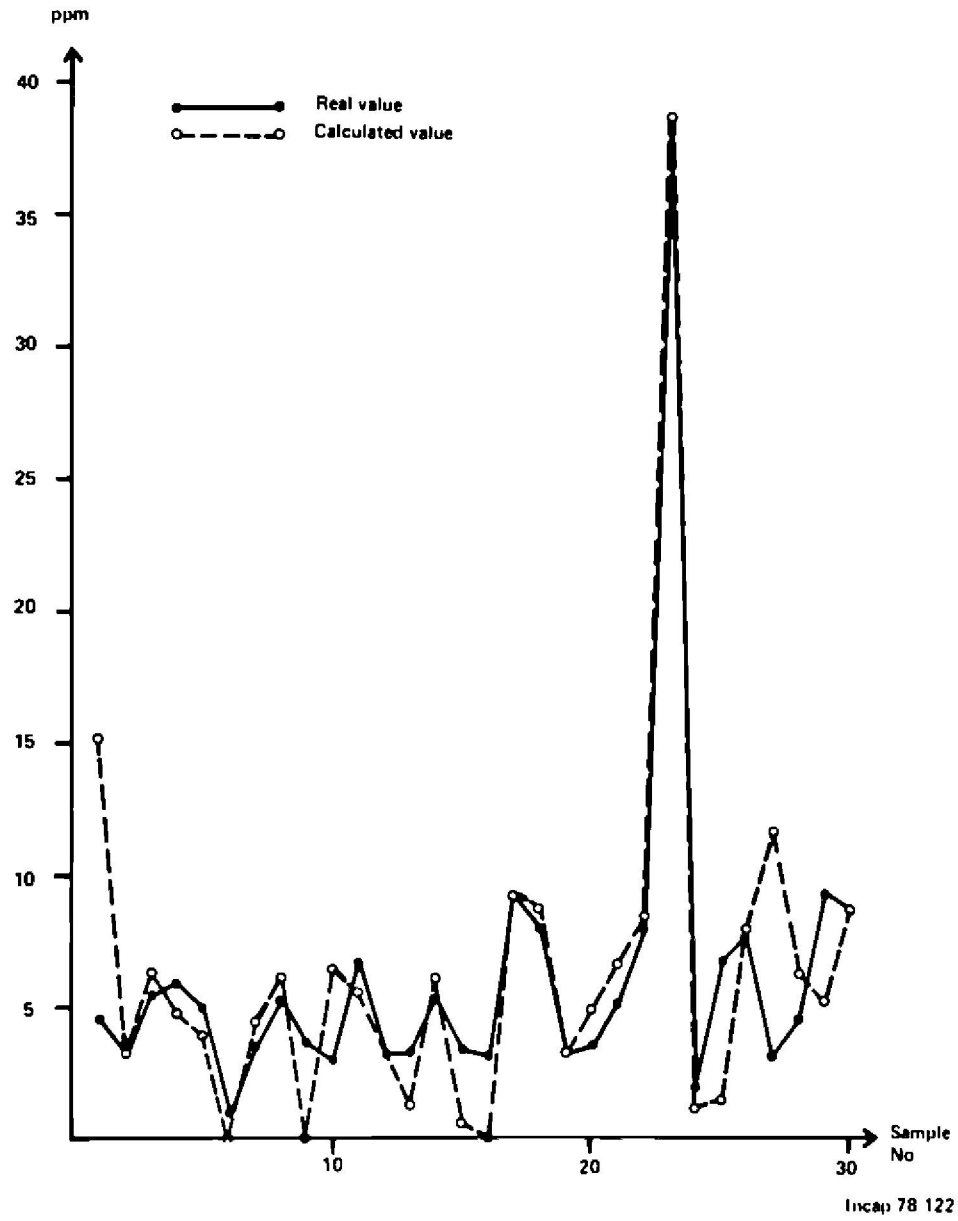

Figure 2. *Total DDT in fat of bovines. Comparison between real and calculated values.*

In Guatemala, the legal limit for total DDT in beef fat is 7 ppm, whereas meat exported to the U.S. has to meet the 5-ppm limit. Using the regression line $Y = 2.54 + 0.61X$, the critical levels for total DDT in blood were calculated as 6.8 ppb for Guatemala and 5.6 ppb for export animals. Theoretically, animals with blood levels higher than these values should be held until blood levels reach an acceptable level. Table 2 summarizes correct and incorrect conclusions using this estimation method.

Even if the possibility of error, according to this study, varies from 10 to 20%, the advantage of using the proposed method for estimating the residue levels in fat before slaughter seems obvious; economic losses would be diminished as well as the potential health hazard for the population. The answer as to the fate of the rejected animals is not easy. Several studies on detoxication of contaminated animals have been published (*2,6*), but further research is certainly needed. In Guatemala, transfer to a clean environment would probably be the immediate answer.

TABLE 2. *Estimation of total DDT residues in 30 fat samples based on analysis of blood.*

	7-ppm limit		5-ppm limit	
	n	% of total	n	% of total
Correctly accepted	21	70	12	40
Correctly rejected	6	20	12	40
Correct conclusions	27	90	24	80
Wrongly accepted	1	3	2	7
Wrongly rejected	2	7	4	13
Wrong conclusions	3	10	6	20

CONCLUSIONS AND RECOMMENDATIONS

Blood analysis may be used to estimate total DDT residues in beef fat before slaughter. It is considered that the proposed method can be used to infer whether a given sample will pass the limit or not. Analysis in triplicate is recommended for samples with residue levels close to the legal limit. It is considered that the proposed method can be used to infer whether a given sample will pass the limit or not.

Comparison of the present data with others published on the same subject indicates variations in the results, but the factors causing these variations are unknown.

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