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Monitoring Wood Shaving Litter and Animal Products for Polychlorophenols Residues, Ontario, Canada, 1978–1986

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Timber is extensively treated with the wood preservative pesticides collectively called the polychlorophenols (PxCP) which include tri-(T3CP), tetra-(T4CP), and pentachlorophenol (P5CP). These treatments are intended to protect lumber against the attacks of wood eating or boring insects and the wood decaying and staining fungi. Wood shavings are a by-product of the lumber industry that have been utilized widely in agriculture for many years as a major bedding litter for poultry, swine, and cattle and a minor litter for other domestic animals. A "musty" taint in chicken eggs was first attributed to the presence of tetrachloroanisole in wood shaving litter by Engle et al (1966). Curtis et al (1972,1974) investigated an outbreak of "musty" flavored meat in chicken raised on wood shaving litter and contaminated with polychlorophenols in the United Kingdom. Complaints were lodged within the Province of Ontario of similar off-flavors in locally produced poultry meat. Many local poultry producers reported having difficulties with (1) the fertility of their breeding flocks and (2) the ineffectiveness of vaccines among poultry raised on wood shavings but which disappeared when raised on cereal straw. An Ontario Ministry of Agriculture and Food service was offered whereby producers could have their wood shavings analysed and receive guidance on the advisability of use. This paper reports on this service started in 1978 for wood shavings, and on a follow-up monitoring program to determine residues of PxCP in domestic animal products.

METHODS AND MATERIALS

Under the service program offered to livestock producers, a technique was described for the collection of representative samples from a truck load of shavings. This included compositing 10-15 sub-samples each of 30 g, taken from throughout the pile. The majority of these wood shaving samples were received from poultry producers with lesser numbers from swine, and beef producers using this by-product for litter in

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their normal farming operations. Some samples were received from those wishing to supply the market with wood shavings free of residues. In all cases, 100 to 500 g samples of dry shavings were received in newly-purchased plastic bags. On some occasions wood shavings were collected by extension staff during farm visits.

In the monitoring program animal tissues were collected at random from Provincially inspected abbattoirs by Ontario Ministry of Agriculture and Food meat inspectors. These samples were obtained from premises across the province. Samples of 25 to 100 g were placed in new plastic bags and delivered to the laboratory within three days. Tissues collected included (1) abdominal fat from chicken, turkey, goat, sheep, beef cattle, rabbit and swine, (2) liver from chicken, and swine, (3) kidney from swine (4) diaphram muscle from beef cattle and swine and (5) wing muscle of chicken. Hen eggs were collected for analysis from a large egg-grading station that served a major sector of the industry. Single eggs were randomly selected for analysis. A total of 69 milk samples were collected by compositing 5 or 6 samples taken from 359 bulk tankers used in a larger study on other pesticide residues in milk.

The method of analysis for wood shavings and animal tissues including eggs was described by Frank et al (1983) and that for milk by Frank et al (1985). Determination by gas liquid chromatography was carried out with three detectors; (i) a Hewlett Packard 5830A and a Tracor 550 with an EC (N^{63}) detector, (ii) a Varian Aerograph 1400 with EC (H^3) detector, and (iii) a Tracor 550 and a Varian Vista 6000 with electroconductivity (Hall) detection system. Recoveries from fortified milk samples were 80 to 85% with limits of detection 0.5 ug/L for P5CP and T_4CP and 1.0 ug/L for T3CP. Recoveries from wood shavings and animal tissues were greater than 90% and the limits of detection were 5 and 1 ug/kg respectively.

RESULTS AND DISCUSSION

Between 1978 and 1986 418 samples of wood shavings were analysed and residues of polychlorophenols ranged from less than 5 ug/kg to 296 mg/kg (Table 1). The highest residues were of P5CP with T4CP (2,3,4,6- tetrachlorophenol) being slightly lower but of the same order of magnitude. The T3CP (2,4,5- and 2,4,6-trichlorophenol) was present at one to three orders of magnitude lower than the other two components.

Of the 418 samples only 20.3% had PxCP residues below 0.1 mg/kg considered to be a negligible level (Table 2). There were 26.8% of samples above 10 mg/kg considered a significant and undesirable level. This was based on the finding by Frank et al (1983) that this level of contamination can lead to off-flavors in the meat. Over the monitoring period no change was observed in the mean residues of PxCP in wood shavings in spite of the

Table 1. Residues of tri, tetra and pentachlorophenol residues in wood shavings and straw used for livestock and poultry litter 1978-86.

Year	No. Samples	Trichlorophenol Mean ± SD (Min. - Max.)	Tetrachlorophenol Mean ± SD (Min. - Max.)	Pentachlorophenol Mean ± SD (Min. - Max.)	Polychlorophenol Mean ± SD (Min. - Max.)
		mg/kg			
Wood Shavings					
1978	58	NA	NA	10.6 ± 19.9 (<0.005 - 97)	
1979	83	NA[1]	NA	13.8 ± 30.0 (<0.005 - 135)	
1980	25	<0.05	5.81 ± 17.4 (<0.005 - 85.0)	12.2 ± 23.1 (<0.005 - 74.4)	17.9 ± 26.3 (<0.05 - 109)
1981	35	0.23 ± 1.27 (<0.005 - 7.52)	4.33 ± 14.9 (<0.005 - 83.0)	11.0 ± 20.1 (<0.005 - 72.5)	15.6 ± 22.8 (<0.005 - 105)
1982	43	0.015 ± 0.029 (<0.005 - 0.130)	3.54 ± 11.2 (<0.005 - 53.7)	10.5 ± 16.8 (<0.005 - 77.8)	14.1 ± 17.8 (0.016 ± 85.0)
1983	41	0.009 ± 0.011 (<0.005 - 0.08)	1.34 ± 5.57 (<0.005 - 35.3)	2.04 ± 4.57 (<0.005 - 22.3)	3.35 ± 8.16 (<0.005 - 45.4)
1984	38	0.22 ± 1.35 (<0.005 - 8.30)	5.08 ± 10.2 (<0.005 - 48.3)	6.49 ± 9.68 (<0.011 - 35.0)	11.8 ± 11.3 (0.027 - 63.4)
1985	47	0.63 ± 4.23 (<0.005 - 29.0)	8.96 ± 35.0 (<0.005 - 240)	11.0 ± 35.1 (<0.005 - 240)	20.6 ± 47.5 (<0.005 - 296)
1986	48	0.17 ± 1.03 (<0.005 - 7.10)	4.12 ± 8.27 (<0.005 - 44.0)	7.02 ± 17.4 (<0.005 - 87.0)	11.31 ± 20.0 (<0.005 - 90.1)
Cereal Straw					
1986	3	<0.001 (<0.001)	0.033 ± 0.016 (<0.017 - 0.050)	0.087 ± 0.063 (0.023 - 0.150)	0.120 ± 0.72 (0.055 - 0.200)

[1]NA = not analysed

Table 2. Distribution of total chlorinated phenol residues in woodshavings between 1978-1986.

Year	Frequency percent of total chlorinated phenols mg/kg in woodshavings						
	<.01	.01 - 0.1	0.1 - 1.0	1.1 - 10	10 - 100	100+	Sample Total
1978		10.3	20.7	43.1	25.9	0.0	58
1979		16.9	27.7	33.7	16.9	4.8	83
1980		24.0	24.0	24.0	24.0	4.0	25
1981		22.8	17.1	28.6	28.6	2.9	35
1982		25.6	11.6	32.6	30.2	0.0	43
1983		39.0	17.1	35.6	7.3	0.0	41
1984		15.8	23.7	26.3	34.2	0.0	38
1985		17.0	17.0	27.7	34.0	4.3	47
1986		20.8	14.6	35.4	29.2	0.0	48
TOTAL		85	83	138	104	8	418
%		20.3	19.9	33.0	24.9	1.9	

Table 3. Polychlorinated phenolic residues in tissues of domestic livestock and poultry 1982-1986.

Species	Tissues	Year	Samples (No.)	Non detected Residues (No.)	Detected Residues (No.)	T3CP Mean ± SD	T4CP Mean ± SD	P5CP Mean ± SD	PxCP Mean ± SD
						ug/kg			
Forage Crops	Animal Feed	1982-84	14	0	14	<5	10 ± 17	17 ± 17	
Bovine (Dairy)	Milkfat	1982	69	3	39	<10	<10	29 ± 24	
Bovine (Beef)	Tallow	1982	1	0	1	<1	<1	7	7
	Abdominal Fat	1985	21	6	15	<1	<1	6 ± 3	6 ± 3
	Abdominal Fat	1986	20	16	4	<1	4 ± 3	37 ± 22	41 ± 24
	Back Muscle	1986	4	4	0	<1	<1	<1	<1
Caprine (Goat)	Abdominal Fat	1985-86	3	1	2	<1	<1	5 ± 1	5 ± 1
Lupine (Rabbit)	Abdominal Fat	1985	9	4	5	<1	<1	5 ± 1	5 ± 1
Porcine (Swine)	Diaphragm Muscle	1984	25	8	17	<1	2 ± 2	5 ± 2	7 ± 4
	Kidney	1984	25	0	25	<1	4 ± 1	7 ± 4	11 ± 6
	Liver	1984	25	0	25	<1	4 ± 1	25 ± 17	29 ± 17
	Abdominal Fat	1985	20	4	16	<1	1 ± 1	5 ± 4	5 ± 4
	Abdominal Fat	1986	20	5	15	<1	4 ± 6	21 ± 26	25 ± 30
	Back Muscle	1986	3	3	0	<1	<1	<1	<1
Ovine (Sheep)	Abdominal Fat	1985	14	5	9	<1	<1	4 ± 3	4 ± 3
	Abdominal Fat	1986	9	7	2	<1	<1	5 ± 1	5 ± 1
Avian (Hen)	Eggs	1986	21	3	18	<1	4 ± 6	35 ± 44	39 ± 41
Avian (Broiler)	Abdominal Fat	1985	11	0	11	<1	4 ± 4	7 ± 4	11 ± 6
	Abdominal Fat	1986	10	2	8	<1	2 ± 2	19 ± 14	21 ± 13
	Back Muscle	1986	3	3	0	<1	<1	<1	<1
Avian (Turkey)	Abdominal Fat	1985	6	0	6	<1	<1	5 ± 2	5 ± 2
	Abdominal Fat Kidney	1986	5	5	0	<1	<1	<1	<1

fact that all uses of the product were cancelled 1st January, 1981 on lumber used around domestic livestock, food and the home (Agriculture Canada, 1980). The majority of wood shavings appeared to come from the raw timbers being cut and planed for a multitude of purposes not necessarily involving agriculture. Hence the changes in registration had no observable impact on the reduction of residue levels of PxCP in wood shavings. The analysis of straw samples, an alternative litter, revealed the presence of PxCP residues, however these were two orders of magnitude lower than wood-shavings.

Shull et al (1981) in a survey of dairy farms in Michigan revealed that wood treated with PxCP was in widespread use on farms in that state. Over the last 6 years the registered uses of PxCP for wood products destined for on farm uses have been cancelled by Agriculture Canada (1980) to avoid bringing PxCP into direct contact with food, animal feed and domestic animals. A study by Frank et al (1983) revealed that feed held indoors near wood shavings with high residues of PxCP absorbed the volatile residues given off. Dried or preserved animal feed analysed between 1982 and 1984 contained residues of T4CP and P5CP of 10 and 17 ug/kg respectively, however these were three orders of magnitude lower than the average levels in wood shaving litter (Table 3). While it was impossible to separate the many probable sources and exposure routes between animal tissue and PxCP, it was believed that wood shavings were one of the most potent. All species of domestic livestock were monitored therefore for PxCP residues. Both T4CP and P5CP residues were measurable in domestic animals and their products (Table 3). The highest levels of PxCP were found in beef fat and hen eggs; 41 and 39 ug/kg. Residues of PxCP in abdominal fats of broilers and turkeys were between <1 and 21 ug/kg. Residues were detected in 86% of eggs, 79% of broilers, and 55% of turkeys (Table 3).

Similar residues of T4CP and P5CP were found in milkfat as in abdominal fat from porcine carcasses. Detectable residues were found in 57% of milkfats, 42% of bovine tissues, and 92% of porcine tissues tested. Residues were slightly lower in tissues from goat, rabbit and sheep (ie. 4 to 5 ug/kg).

The levels of T4CP and P5CP were several order of magnitude higher in wood shavings than in plant products used for animal feed or litter and possibly reflect residues that could be found in wooden structure used to house domestic livestock. Many workers (Engel et al, 1966; Curtis et al, 1972, 1974; Frank et al, 1983) have described the effects on meat quality and flavour. Other workers (Monro et al, 1977) have described poisoning of domestic animals.

It appears that wood shaving are potent source of contaminants that can at least reduce food quality. The reductions in the registered use pattern of PxCP carried out thus far were not reflected as reductions in residues of wood shavings.

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