PESTICIDE AND HEAVY METAL RESIDUES IN CANADIAN MEATS

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Introduction

The need to organize a national surveillance program for agricultural pesticide residues was recognized a number of years ago with the announcement that such pesticides accumulated in living tissue. This intensive program was later extended to include such materials as mercury, etc., when it was suggested that a rather high concentration of mercury was determined in fresh water fish, following the incidents and experiences of Japan and Scandinavia.

There are approximately 150 Establishments in Canada slaughtering poultry and red meats, i.e., beef, pork, sheep, lambs and horses. With the aid of the seven regional offices, schedules have been worked out whereby a sample of depot fat and liver tissue is submitted from a number of animals per plant at periodic preplanned intervals. The availability of laboratory facilities and laboratory manpower is, in such a program, the limiting factor. The sample is identified by the Inspector in Charge so that the animal owner and district where it was raised may be traced, in the event that there is need to do so. Finally, the samples are fast frozen and packaged for shipping to the laboratory. The Plant Inspector is charged with the responsibility of packaging the samples, with dry ice if necessary, to insure that the samples arrive at the laboratory in a frozen condition. In addition to this program, we have undertaken a monitoring program on meat and meat food products imported into Canada for residual pesticide concentrations.

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Method of Analysis I - Pesticides

The laboratory is analysing samples of depot fat for the following pesticide residues (Fig. 1). We have included, in this list, the official tolerance levels as published by the Health Protection Branch. All of the organophosphate pesticides have been lumped together under the heading, "organophosphates". With the use of a phosphorous detector, the gas chromatogram will yield a peak at a point if organophosphate residues are present. Identification of the residue then takes place by running standard preparations through the instrument and matching up the peaks. The reverse procedure is followed when determining the presence of chlorinated hydrocarbon pesticide compounds. The analysis is performed by means of gas chromatography, and the details of the procedure are well described in the literature.[1]

The minimum detectable levels for some of these pesticides are - lindane 0.001 ppm; heptachlor and heptachlor epoxide, aldrin, -0.002 ppm; dieldrin, DDE, DDD, 0.004 ppm; o, p' - DDT - 0.006 ppm. For practical purposes, all levels found below 0.006 ppm (6 ppb) were reported as "traces". Those analyses which bear the term "not found" represent samples where all evidence of pesticide residue was absent or was below minimum detectable levels.

Method of Analysis II - Heavy Metal Residues

Interest in trace quantities of mercury in foods has, as we all know, increased sharply in recent years. Mercury and organomercurial compounds have long been used in agriculture and the pulp and paper industry, and more recently in the chlor-alkali industry.

The high toxicity of the organomercury compounds, i.e., methylmercury compounds, has spurred the development of extremely sensitive analytical methods. Our laboratories have chosen the Cold Vapor Method Atomic Absorption Spectrometry.

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This procedure is very sensitive and is especially useful in the determination of trace metals in foods.[2] In addition, our laboratories are subjecting samples of tissue to analysis for copper, lead and cadmium. Figure No. 2 lists the maximum permitted tolerance of such materials allowed in animal liver tissue. You will note that the number opposite cadmium is listed as 1.0 ppm. At present, Canada does not have an official maximum permitted tolerance for cadmium. However, amongst those who are interested in this material, an unofficial working level has been more or less agreed upon. From the data which we will present, you will see that this quantity has never been exceeded.

Of late, there has been an interest expressed by those in the meat industry to permit the addition of small quantities of selenium in animal feeds in order to combat a pathological condition known as white muscle disease in areas where the natural selenium level is not sufficient for the prevention of this disease. As a result, we are beginning to analyze tissue for the presence of selenium in order to collect some data with regard to the degree of background levels present, in the event that selenium becomes a permitted additive to animal feeds. At this point, meaningful data is not available. At the present time, no decision has been reached, I am given to understand, regarding the question of permitting the addition of selenium to animal feeds. Of interest, in this regard, is the fact that there is no epidemiological evidence that the oral ingestion of selenium is associated with a carcinogenic hazard in man.

The data which is being presented represents some of the data accumulated during the period July 1971 - June 1972.

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Results - Heavy Metals

When it was decided to analyze meat for the residual mercury content, we did not have any previous information with regard to the most suitable tissue with which to work. Consequently, several experiments were conducted using the masseter face muscle, kidney tissue and liver tissue from the same animal.

The results indicate that as the levels of mercury were so low in all three tissues, there appears to be little reason to choose one over the other (Fig. 3). It was subsequently decided to use liver tissue as the body tissue for this analysis, partly due to the fact that the Food and Drugs Act lists maximum tolerances in terms of liver tissue. The literature suggests that mercury accumulates to a greater extent in the kidneys. This conclusion, however, is based on a single injection of a high level of mercury and these findings may not be valid in the case of prolonged feeding at low levels.

Our laboratories have analyzed 675 samples of liver tissue for mercury, lead, copper and cadmium. It was possible to detect these materials in all 675 samples. These analyses were conducted on liver tissue stemming from beef, pork and mutton animals. Figure No. 4 shows the range in ppm of the tissue samples analyzed. None of the samples analyzed were above official tolerance levels. In 4 cases, it was noted that the content of copper in liver tissue from sheep slaughtered in the spring approached the maximum tolerance. Investigation revealed that these animals had been treated with copper sulphate to correct a worm condition common to sheep. This latter incident offered an opportunity to test our identification system, which would be required to identify the source of an animal if high pesticide residue levels or heavy metal levels were encountered. Since the initiation of these programs, it has not been necessary to trace back any samples. It would appear, therefore, from analysis of the data collected, that at the present time meat and meat food products manufactured

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from domestic meat supplies do not constitute a health hazard,nor does it seem that such meats contribute significantly to the total intake of such heavy metals.

Pesticide Residue

Figure No. 5 shows the incidence of various pesticides isolated from various meat samples. The polychlorinated biphenyl, arochlor, has the highest incidence other than DDT and its metabolites, and is represented by 24 isolations out of 204 tissue samples analyzed. Others, such as lindane, methoxychlor and chlordane, can be said to be present in roughly 2 - 3% of the samples analyzed. With regard to arochlor, the range of concentration found extends from <0.006 ppm to 0.085 ppm, chlordane from <0.006 ppm to 0.075 ppm. One sample yielded a 0.87 ppm concentration of methoxychlor.

We have presented the data on DDT in the fashion shown (Fig. 6). The two columns on the right indicate the number of samples positive for o'p' - DDT and pp - DDT, whereas, the two left-hand columns indicate the incidence of metabolites. We have observed that since the suspension of the use of DDT, there has been a slightly perceptible shift from the incidence of DDT to the metabolites. In other words, the net DDT concentration in the environment, as represented by DDT in meats, does not seem to have been reduced, although we have stopped pumping more into the environment. However, that which is present is being altered to the DDE and DDD (metabolite) form. We have not subjected our figures to statistical analysis; however, we feel that statistical analysis would bear this out.

In regard to concentration, even if one were to sum the highest concentration found of each compound, the resultant sum is less than 50% of the official tolerance for DDT and metabolites.

As you can see from the foregoing data, we are dealing with very small concentrations.

Conclusions

From the data collected from analysis of samples of animal tissue, there does not appear to be any health hazard associated with the consumption of meats raised in Canada with regard to pesticide residues or heavy metal residues. There has been, we sense, a reduction in emphasis and sense of urgency with regard to mercury contamination of foods of late. However, we intend to continue our monitoring programs in order to be able to give consumers continuing assurances of the wholesomeness of the meat and meat products that they buy.

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References

1. Sachenbrocher, P.W. and Etrobichon, D.J.
Extraction and Gas Chromatographic Analysis of Chlorinated Insecticides from Animal Tissue
Jour. Agric. and Food Chem. 15, No. 1, p. 168, Jan/Feb 1967

2. Widmark, G.
Organomercury Fungicide Residue Analysis Circulation
J. Ass. Off. Analyt. Chem. 51, p. 367, 1968

3. Somers, E. and Smith, D.M.
Source and Occurrence of Environmental Contaminants
Fd. Cosmet. Toxicol 9: 185 - 193, 1971

4. Analytical Methods for Pesticide Residues in Food, published by the Food and Drug Directorate, Department of National Health and Welfare, Ottawa, Ontario, 1969. Available from The Queen's Printer, Ottawa, Ontario

5. Swensson, A. and Ulfvarson, U.
Distribution and Excretion of Mercury Compounds in Rats over a Long Period After a Single Injection:
Acta. pharmacol and toxicol 26: 273 - 283, 1968

6. Yasushi, T. et al
Distribution of Inorganic, Aryl, and Alkyl Mercury Compounds in Rats
Toxicol. App. Pharmacol 13: 156 - 164, 1968

7. Ellis, R.W. and Fang, S.P.
Elimination, Tissue Accumulation, and Cellular Incorporation of Mercury in Rats Receiving an Oral Dose of ^{203}Hg - Labelled Phenylmercuric Acetate and Mercuric Acetate
Toxicol. App. Pharmacol 11: 104 - 113, 1967

8. Brown, J.R. et al
Studies on the Toxicity and Metabolism of Mercury and its Compounds
Med. Ser. Journ. 23: 1089 - 1110, 1967

9. Swensson, A. and Ulfvarson, U.
Distribution and Excretion of Various Mercury Compounds after Single Injections in Poultry
Acta. Pharmacol and Toxicol. 26: 259 - 272, 1968

FIG. I

PESTICIDE	MAXIMUM TOLERANCE PPM
LINDANE	2.0
BHC	0.25
DDT AND METABOLITES	7.0
TOXAPHENE	7.0
METHOXYCHLOR	3.0
ALDRIN	0.25
DIELDRIN	0.25
ENDRIN	0.1
HEPTACHLOR	0.25
HEPTACHLOR EPOXIDE	0.25
CHLORDANE	0.25
PCB AROCHLOR	0.5
ORGANOPHOSPHATES	

FIG. 2

MAXIMUM TOLERANCES OF HEAVY METALS

IN LIVER TISSUE

HEAVY METAL	MAXIMUM PPM PERMITTED
LEAD	2.0
COPPER	150.0
MERCURY	0.5
CADMIUM	⁂ 1.0
ZINC	100.0

⁂ UNOFFICIAL WORKING STANDARD

FIG. 3

MERCURY IN PPM

LIVER	KIDNEY	MUSCLE
0.10	0.010	0.006
0.009	0.010	0.002
0.004	0.012	0.004
0.005	0.012	0.005
0.022	0.010	0.006
0.005	0.007	0.006
0.006	0.015	0.020
0.021	0.022	0.007
0.023	0.010	0.006
0.008	0.011	0.011

FIG. 4

PPM RANGE OF HEAVY METAL RESIDUES

MERCURY ppm (0.5)	LEAD ppm (2)	COPPER ppm (150)	CADMIUM ppm (1.0)
0.0 - 0.3 ppm	0.0 - 1.8 ppm	0.0 - 130 ppm	0.0 - 0.96 ppm

* DATA BASED ON 675 SAMPLES.

FIG. 5

INCIDENCE OF VARIOUS PESTICIDE RESIDUES

PESTICIDE	NO. OF POSITIVE SAMPLES	PESTICIDE	NO. OF POSITIVE SAMPLES
LINDANE	5/204	BHC	2/204
TOXAPHENE	1/204	METHOXYCHLOR	4/204
ALDRIN	0/204	DIELDRIN	0/204
ENDRIN	0/204	HEPTACHLOR	0/204
HEPTACHLOR EPOXIDE	2/204	CHLORDANE	6/204
PCB - AROCHLOR	24/204	ORGANO-PHOSPHATES	1/204

FIG. 6

DDT AND METABOLITES

	DDE	DDD	o'p' - DDT	pp - DDT
POSITIVE SAMPLES	176/204	88/204	35/204	144/204
TRACE CONCENTRATION (BELOW .006 ppm)	38/204	25/204	18/204	36/204
HIGHEST CONCENTRATION FOUND	0.596 ppm	0.630 ppm	0.506 ppm	1.302 ppm