PARATHION (058)

EXPLANATION

Parathion was originally evaluated by the JMPR in 1965 and has been reviewed several times since. In 1991 it was extensively re-evaluated and recommendations were made to replace general MRLs for fruits and vegetables by MRLs for specific commodities.

At the 25th Session of the CCPR (1993, ALINORM 93/24A, para 81) the delegation of Germany informed the Committee that the manufacturer would seek re-registration and indicated that a higher MRL for pome fruit was necessary. The proposed MRL was held at step 7B by the 1994 CCPR (ALINORM 95/24, para 150) pending the 1995 JMPR review. At the 27th Session of the CCPR (1995, ALINORM 95/24A, para 103) the manufacturer indicated that additional studies on apples were in progress and would not become available until 1996.

The 1994 CCPR (ALINORM 95/24, para 149) decided to request the JMPR to reconsider the limit of determination of parathion. It also decided to advance the proposals for cotton seed, maize, sorghum, soya bean and sunflower seed to Step 7C to await further information from the USA on registered uses.

Information was provided to the Meeting by the manufacturer on the current use patterns in the USA, supervised trials on cereals and canola, processing trials, freezer storage stability studies and validation of analytical method. Australia, The Netherlands and Peru provided information on current use patterns and data on monitoring.

The current review was scheduled to deal with the commodities held at Step 7B or 7C: apple, cotton seed, maize, sorghum, soya bean (dry) and sunflower seed. The Meeting was aware of a pending review of parathion in the EU and that residue trials were under way in Europe. The Meeting reviewed only those studies that included the commodities at Step 7, analytical methods (with reference to the limit of determination), a report on metabolism in plants and recent reports on estimates of dietary intake.

METABOLISM AND ENVIRONMENTAL FATE

Plant metabolism

Wheat plants were treated with two foliar applications of [*phenyl*-^{14}C]parathion at 1.3 kg ai/ha and grain and straw were harvested 7 days after the final application (Sanger, 1993). The composition of the ^{14}C residues in the grain and straw is shown in Table 1; 72% and 82% of the ^{14}C was extractable from straw and grain respectively with aqueous methanol.

Parathion was the major compound in the residue, and constituted 62% of the ^{14}C in the grain. Paraoxon was not detected in the grain and was a minor component of the residue in the straw. When the unextractable fraction from the straw was digested chemically or with enzymes, additional parathion (1.1 mg/kg) and paraoxon (0.99 mg/kg) were released from the lignin fraction. It is possible that the paraoxon was produced from parathion during the digestion procedure.

Table 1. Composition of the residues in wheat grain and straw harvested 7 days after two applications of [*phenyl*-^{14}C]parathion at 1.3 kg ai/ha (Sanger, 1993).

Residue	Grain		Straw	
	^{14}C as parathion, mg/kg	^{14}C as % of ^{14}C in grain	^{14}C as parathion, mg/kg	^{14}C as % of ^{14}C in straw
Total ^{14}C	10.6		126	
Extractable ^{14}C		82		72
Parathion	6.6	62	46	37
Paraoxon			1.2	0.93
4-nitrophenol	0.79	7.4	13	11
Diethyl 4-acetylaminophenyl phosphate			1.0	0.82
4-nitrophenyl-â-D-glucopyranoside	0.041	0.39	0.73	0.58
O-ethyl *p*-nitrophenyl phosphorothioate	0.027	0.25		
Complex anionic polar metabolites	0.47	4.4	14	11

METHODS OF RESIDUE ANALYSIS

Analytical methods

A suitable procedure was presented (Cassidy, 1991) for the regulatory determination of residues of parathion, paraoxon and 4-nitrophenol in a range of substrates. The sample was extracted with aqueous methanol acidified with HCl and the entire mixture refluxed for 30 minutes. The solution was filtered and concentrated, removing the methanol. Saturated sodium chloride was added before extraction with ethyl acetate. The ethyl acetate was concentrated and parathion and paraoxon determined by GLC with an FPD. An aliquot of the ethyl acetate extract was cleaned up on a Florisil Sep-Pak and the 4-nitrophenol residue was determined by HPLC with UV detection at 315 nm. Variations of the method were needed for some substrates. The limit of quantification was 0.05 mg/kg. Recoveries were found to be satisfactory at this and higher concentrations in about 50 substrates including vegetables, fruits, nuts, cereals, processed commodities and feeding-stuffs.

Keller (1992) used the above method in studies of storage stability with an additional clean-up to remove lipids by gel permeation chromatography. The LOD for each compound was 0.05 mg/kg.

A similar method was used for the analysis of canola seed (Kludas, 1993). Analytical recoveries were 81-92% for parathion and 104-116% for paraoxon at fortification levels of 0.05 and 5.0 mg/kg.

Norby (1993a) described a similar method for parathion and paraoxon residues in cereal commodities. Wheat grain, flour, middlings and shorts were extracted with aqueous acetone, and wheat bran, grain dust, straw and forage with methanol, both extractants acidified with HCl. The analysis were completed as above, but with GLC on a capillary column. The method was validated by testing recoveries at 0.02, 0.05, 0.5 and 5 mg/kg, with the results shown in Table 2. Separate analyses of the commodities spiked at 5 mg/kg with parathion or paraoxon alone verified that there was no conversion of one to the other during analysis. The LOD was 0.02 mg/kg.

Norby (1993b) tested the method on canola and its processed commodities. Fortifications at 0.02 mg/kg of canola seed, crude oil, refined oil and canola meal produced unacceptably high recoveries of paraoxon but recoveries at 0.05 mg/kg were acceptable. The LOD for paraoxon was therefore 0.05 mg/kg and that for parathion 0.02 mg/kg. The results are shown in Table 2.

Table 2. Analytical recoveries of parathion and paraoxon in cereal and canola commodities (Norby, 1993a,b).

Commodity	Fortification, mg/kg	Parathion recoveries, %			Paraoxon recoveries, %		
		Range	Mean	n	Range	Mean	n
Wheat grain	0.02, 0.05, 0.50, 5.0	73-112	95	9	90-101	95	9
Wheat straw	0.02, 0.05, 0.50, 5.0	90-108	96	9	92-119	106	9
Wheat forage	0.02, 0.05, 0.50, 5.0	85-111	96	9	93-104	99	9
Wheat bran	0.02, 0.05, 0.50, 5.0	67-99	86	9	87-107	94	9
Wheat flour	0.02, 0.05, 0.50, 5.0	75-113	85	9	95-112	101	9
Wheat middlings [1]	0.02, 0.05, 0.50, 5.0	79-123	93	9	81-119	93	9
Wheat shorts [2]	0.02, 0.05, 0.50, 5.0	85-103	91	9	86-123	104	9
Wheat grain dust	0.02, 0.05, 0.50, 5.0	73-116	85	9	88-115	95	9
Canola seed	0.02	99 108		2	128 130		2
Canola seed	0.05, 0.5, 5.0	79-94	88	7	101-115	109	7
Canola meal	0.02	85 86		2	121 127		2
Canola meal	0.05, 0.5, 5.0	82-95	88	7	100-116	107	7
Canola refined oil	0.02	92 94		2	104 165		2
Canola refined oil	0.05, 0.5, 5.0	74-80	77	7	81-97	89	7
Canola processing waste	0.02	90 94		2	109 114		2
Canola processing waste	0.05, 0.5, 5.0	74-84	79	7	83-103	93	7

[1] middlings: smaller sieving fraction than bran.
[2] shorts: milled fraction of the middlings retained on the larger sieves.

Price (1991) used a method referred to as MKL-006-88-05. Samples are extracted with aqueous methanol and filtered. The methanol is evaporated and the aqueous phase extracted with ethyl acetate. The concentrated ethyl acetate extract is analysed for parathion and paraoxon by GLC with an FPD. An aliquot of the ethyl acetate extract is cleaned up on a Florisil Sep Pak column and nitrophenol is determined by HPLC.

Sparacino (1992) described similar methods, with validation, for residues of parathion and the two metabolites in wheat, sunflower seed oil, wheat straw and wheat flour. Plant samples are extracted with aqueous methanol or acetone acidified with HC1 and the mixture refluxed for 1 hour. After filtration and evaporation of the solvent the residues are extracted with ethyl acetate and parathion and paraoxon determined as before. An aliquot of the ethyl acetate solution is cleaned up on a small Florisil column and the 4-nitrophenol determined by HPLC. The validated LOD for the three compounds was 0.05 mg/kg. For the analysis of sunflower seed oil a solvent partition step with hexane/acetonitrile was needed to separate the residues from the oil. To confirm identification capillary GC-MS was used with selected ion monitoring at m/z = 109, which corresponds to a fragment of 4-nitrophenol and occurs with all three compounds.

Sparacino found that the determination of parathion and 4-nitrophenol residues was generally

straightforward, but the behaviour of paraoxon during GLC was inconsistent. It was necessary to prime the packed columns with paraoxon and plant extracts and to eliminate column voids for satisfactory results. Analytical recoveries from wheat, wheat straw, wheat flour and sunflower seed oil were parathion (0.05-2 mg/kg) 75-165%, mean 95% (n=30); paraoxon (0.05-0.5 mg/kg) 78-185%, mean 120% (n=30); 4-nitrophenol (0.05-2 mg/kg) 63-162%, mean 108% (n=31).

Szorik (1991) tested the proposed regulatory method for interferences from other pesticide residues. Approximately 200 pesticides were checked for their behaviour on GLC, and those that showed a potential for interference were tested through the method with a variety of substrates. Fenthion and chlorpyrifos came through the extraction and clean-up and interfered with the parathion peak, and phosphamidon, chlorpyrifos-methyl and parathion-methyl interfered with the paraoxon peak.

Stability of pesticide residues in stored analytical samples

Keller (1992) determined the stability of parathion, paraoxon and nitrophenol added at 1 mg/kg as a mixture to macerated snap beans, kidney beans and cotton seed and stored in a freezer for 24 months. The results are shown in Table 3. Control samples were stored for the same times as the test samples and fortified on the day of analysis. The test sample results were then corrected for the recoveries obtained with the companion controls. All test and control samples were analysed in duplicate.

Price (1991) used similar methods to determine the stability of parathion, paraoxon and nitrophenol added at 1 mg/kg to macerated almond kernels, apples, clover, oranges, plums, spinach, strawberries, sunflower seed and sweet peppers and stored at approximately -20°C for 24 months. The results are shown in Table 4.

parathion

Table 3. Freezer storage stability of parathion, paraoxon and nitrophenol added at 1 mg/kg to macerated snap beans, kidney beans and cotton seed and stored at approximately -20°C for 24 months (Keller, 1992).

Storage time, days	% remaining								
	SNAP BEANS			KIDNEY BEANS			COTTON SEED		
	parathion	paraoxon	nitrophenol	parathion	paraoxon	nitrophenol	parathion	paraoxon	nitrophenol
0	106	100	90	128	109	113	100	95	105
30	90	97	104	99	103	93	102	102	102
60	89	89	92	105	100	112	97	100	103
90	102	109	107	102	102	126	95	104	95
120	90	74	109	107	100	109	99	95	89
180	98	121	108	84	83	103	108	69	99
360	104	32	104	100	95	112	101	102	102
540	93	26	103	100	99	91	93	104	113
720	91	29	123	94	84	92	102	98	86

Table 4. Freezer storage stability of parathion, paraoxon and nitrophenol added at 1 mg/kg to macerated almond kernels, apples, clover, oranges, plums, spinach, strawberries, sunflower seed and sweet peppers and stored at approximately -20°C for 24 months (Price, 1991).

Storage time, months	% remaining								
	ALMOND KERNELS			APPLES			CLOVER		
	parathion	paraoxon	nitrophenol	parathion	paraoxon	nitrophenol	parathion	paraoxon	nitrophenol
0	95	99	91	101	102	101	95	109	99
1	84	96	108	99	99	95	101	99	109
2	102	87	93	95	91	96	119	108	106
3	88	104	100	96	93	122	103	77	81
4	96	104	95	92	91	98	112	84	103
6	83	88	94	98	88	90	101	84	105
12	90	99	94	89	79	106	98	78	97
18	80	96	104	98	101	97	101	74	120
24	75	90	106	119	106	132	97	75	116
	ORANGES			PLUMS			SPINACH		
	parathion	paraoxon	nitrophenol	parathion	paraoxon	nitrophenol	parathion	paraoxon	nitrophenol
0	104	104	103	107	108	88	117	120	106
1	94	98	109	97	98	90	88	92	100
2	93	94	103	101	102	108	92	86	101
3	101	103	89	98	98	110	93	89	100
4	98	95	100	104	105	105	115	81	98
6	114	102	101	106	100	95	96	76	86
12	99	96	79	114	106	102	108	75	111
18	99	96	97	92	90	81	74	74	102
24	78	70	81	101	89	89	95	60	92
	STRAWBERRIES			SUNFLOWER SEED			SWEET PEPPERS		
	parathion	paraoxon	nitrophenol	parathion	paraoxon	nitrophenol	parathion	paraoxon	nitrophenol

parathion

Storage time, months	% remaining								
0	115	112	104	97	90	93	112	105	103
1	98	97	102	98	87	95	89	79	98
2	94	91	98	90	90	102	85	88	90
3	97	97	106	92	86	92	105	94	97
4	101	107	100	99	98	106	98	77	84
6	109	95	93	102	87	98	83	72	95
12	94	86	89	88	82	91	89	56	89
18	98	92	88	104	104	105	113	77	113
24	98	94	87	77	79	92	93	98	110

USE PATTERN

Information provided on the registered uses of parathion in the USA is shown in Table 5. All aerial applications of EC formulation.

Parathion is registered in the USA for use by aerial application only on field crops for the control of alfalfa weevils, aphids, armyworms, beetles, brown wheat mites, caterpillars, crickets, cutworms, European corn borers, grasshoppers, hoppers, leaf miners, Lygus bugs, moths, spider mites, spittlebugs, sunflower moths, thrips and webworms.

Table 5. Registered uses of parathion in the USA. All aerial applications of EC formulation.

Crop			PHI days
	Rate, kg ai/ha	Number	
Alfalfa	0.28-0.84		15[1]
Barley	0.28-0.84		15[1]
Cotton	0.28-1.1		7[2]
Maize	0.28-1.1		12[3]
Rape seed, canola	0.56		28[4]
Sorghum	0.28-1.1		12[3]
Soya bean	0.28-0.85		20[5]
Sunflowers	0.56-1.1	4	30
Sweet corn	0.28-0.84		12
Wheat	0.28-0.84		15[1]

[1] Do not apply within 15 days of harvest, cutting or forage
[2] Do not feed cotton trash to dairy animals or animals being finished for slaughter within 15 days of application
[3] Do not apply within 12 days of harvest, cutting or forage
[4] Do not graze treated fields or feed treated forage, threshing waste or seed screenings to livestock
[5] Do not apply within 20 days of harvest, cutting or forage

RESIDUES IN FOOD IN COMMERCE OR AT CONSUMPTION

Estimates of the intake of parathion in the Australian diet were reported by Stenhouse (1992). The estimated daily intakes for diets based on the average energy intake were adult male 0.0097 ì g/kg bw; adult female 0.0121 ì g/kg bw; boy aged 12 0.0138 ì g/kg bw; girl aged 12 0.0149 ì g/kg bw; child aged 2 0.0259 ì g/kg bw; infant aged 9 months 0.0206 ì g/kg bw. These intakes should be compared with the current parathion ADI of 5 ì g/kg bw.

Dejonckheere *et al*. (1993) estimated the dietary intake of parathion in the Belgian diet arising from food commodities of plant origin. For a 60 kg person the average residue in food prepared for consumption gave an estimated intake of 0.198% of the ADI.

Penttilä and Siivinen (1995) evaluated the dietary intake of pesticide residues, including parathion, in Finland. In 1992 the estimated dietary intake of parathion from domestic and imported foods was 0.005 ì g/kg bw. In 1993 only foods produced in Finland were analysed and no parathion residues were detected.

APPRAISAL

Parathion was originally evaluated by the JMPR in 1965 and was extensively re-evaluated in 1991.

At the 25th Session of the CCPR (1993, ALINORM 93/24A, para 81) the delegation of Germany informed the Committee that the manufacturer would seek re-registration and indicated that a higher MRL for pome fruit was necessary. The proposed MRL was held at step 7B by the 1994 CCPR (ALINORM 95/24, para 150) pending the review by the 1995 JMPR. At the 27th Session of the CCPR (1995, ALINORM 95/24A, para 103) the manufacturer indicated that additional studies on apples were in progress and would not become available until 1996.

The 1994 CCPR (ALINORM 95/24, para 149) decided to request the JMPR to reconsider the limits of determination of parathion. It also decided to advance the proposals for cotton seed, maize, sorghum, soya bean and sunflower seed to Step 7C awaiting further information from the USA on registered uses.

Information was provided to the Meeting by the manufacturer on the current use patterns in the USA and on supervised trials on cereals and canola, supported by processing trials, freezer storage stability data and validation of analytical methods. The current review was scheduled to deal with commodities held at Step 7B or 7C: apple, cotton seed, maize, sorghum, soya bean (dry) and sunflower seed. The Meeting reviewed only those studies that included the commodities at Step 7, analytical methods to deal with the question on the limits of determination, a report on plant metabolism and recent reports on estimates of dietary intake.

In a plant metabolism study parathion was the major component of the residue (62% of the ^{14}C) in wheat grain harvested 7 days after the second application of ring-labelled parathion to the plant. Paraoxon was not detected in the grain and 4-nitrophenol comprised 7.4% of the ^{14}C. Parathion, paraoxon and 4-nitrophenol accounted for 37%, 1.2% and 13% of the ^{14}C in the wheat straw respectively. In the straw and grain 72% and 82% respectively of the ^{14}C was extractable with aqueous methanol.

The GLC methods used in the USA to determine residues of parathion and paraoxon in the majority of crops in the 1991 Evaluations had LODs of 0.05 mg/kg for each compound.

Information was provided on a procedure suitable as a regulatory method for determining residues of parathion, paraoxon and 4-nitrophenol in a range of substrates. The sample is extracted with aqueous methanol acidified with HCl, the entire mixture is refluxed for 30 minutes, then filtered

and concentrated, removing the methanol. The residues are extracted into ethyl acetate, the extract is concentrated and the parathion and paraoxon residues determined by GLC with an FPD. An aliquot of the ethyl acetate extract is cleaned up on a Florisil Sep-Pak and the 4-nitrophenol residue determined by HPLC with UV detection at 315 nm. Variations of the method are needed for some substrates. The LOD for each compound was 0.05 mg/kg. Recoveries were found to be satisfactory at this concentration and higher in approximately 50 substrates including vegetables, fruits, nuts, cereals, processed commodities and feeding materials.

A similar procedure for parathion and paraoxon residues in cereal commodities was described in another report. The LOD was 0.02 mg/kg. When the method was applied to canola and its processed commodities the LOD for parathion was 0.02 mg/kg, but that for paraoxon was 0.05 mg/kg.

When additional identification of residues is needed, capillary GC-MS may be used with selected ion monitoring at m/z = 109, which corresponds to a fragment derived from 4-nitrophenol and occurs with parathion, paraoxon and 4-nitrophenol.

The regulatory method was tested for interferences from other potential pesticide residues. Fenthion and chlorpyrifos came through the extraction and clean-up and interfered with the parathion GLC peak. Similarly phosphamidon, chlorpyrifos-methyl and parathion-methyl interfered with the paraoxon peak.

The storage stability of parathion, paraoxon and nitrophenol residues was measured after adding a mixture of 1 mg/kg of each to macerated snap beans, kidney beans, cotton seed, almond kernels, apples, clover, oranges, plums, spinach, strawberries, sunflower seed and sweet peppers and storing in a freezer for 24 months at approximately -20°C. The three compounds were stable under these conditions, but occasionally the amount of paraoxon remaining after long-term storage was less than 70%, particularly in snap beans.

Parathion is registered in the USA only for aerial application to field crops. The use patterns reported in 1995 for alfalfa, cotton, maize, sorghum, soya beans, sunflowers and wheat are essentially the same as those recorded in the 1991 Residue Evaluations. Use patterns for the additional crops barley, rapeseed or canola and sweet corn have now been reported.

Dietary intake studies in Australia, Belgium and Finland showed that the dietary intake of parathion was much less than the current ADI.

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