ETOFENPROX (185)

IDENTITY

Chemical name: 2-(4-ethoxyphenyl)-2-methylpropyl 3-phenoxybenzyl ether (IUPAC).
1-[[2-(4-ethoxyphenyl)-2-methylpropoxy]methyl]-3-phenoxybenzene (CA)

CAS No: 80844-07-1

Synonyms: MTI-500; "Trebon"

Structural formula:

Molecula formula: $C_{25}H_{28}O_3$

Molecular weight: 376.49

Physical and chemical properties

Pure active ingredient

Physical state:	white crystalline powder		
Vapour pressure:	2.4×10^{-4} mm Hg at 100°C		
Melting point:	36.4 - 38.0°C		
Octanol/water partition coefficient:	log P_{ow} = 7.05 at 25°C		
Solubility: (g ai/100 ml sovent)	water	$<10^{-7}$	at 25°C
	acetone	780	at 25°C
	ethanol	15	at 25°C
	acetonitrile	64	at 10°C
	n-hexane	270	at 25°C
	xylene	480	at 25°C
	carbon disulphide	340	at 10°C
	methanol	6.6	at 25°C
	chloroform	900	at 25°C
	dichloromethane	370	at 10°C
	benzene	240	at 10°C
	tetrahydrofuran	280	at 10°C

ethyl acetate 600 at 25°C

Specific gravity: solid (23.0°C): 1.157 g/ml
liquid (40.1°C): 1.067 g/ml

Hydrolysis: stable in aqueous 1N NaOH or 1N HCl for at least 10 days.

Stability to heat: no loss during at least 3 months storage at 80°C. Partial degradation at 100°C.

Photolysis: When [^{14}C]etofenprox was exposed to high-intensity lamps at 30000 lux, the half-life was approximately 4 days.

Technical material

Purity: Typically 96.3% etofenprox. Impurites <1%

Formulations

Wettable powder	20%
Emusifiable concentrate	20%

USE PATTERN

Etofenprox is used as an insecticide against many insect pests on a broad range of crops such as rice, fruits, vegetables, corn, soya beans and tea. The compound is active against Lepidoptera, Hemiptera, Coleoptera, Diptera, Thysanoptera and Hymenoptera at low rates. The compound is particularly effective against strains of rice green leefhopper and planthoppers resistant to organophosphorus or carbamate insecticides owing to its pyrethroid-like activity.

Etofenprox is mostly formulated as a 20% wettable powder or 20% emulsifiable concentrate for use on all types of crops, but in some countries 10 or 30% formulations are used.

Etofenprox is registered in several countries. Registered use patterns are shown in Table 1.

Table 1. Registered uses of etofenprox.

Crop	Country	Application			PHI, days
		No	Rate, kg ai/ha	Spray conc., kg ai/hl	
Apple	Hungary	1-2	0.15	0.01-0.05	14
	Japan	1-3	1.0-1.2	0.02	14
	Poland	1	0.14	0.009	14
Cabbage	Japan	1-3	0.4-0.5	0.02	3
	Spain	3-4	0.18-0.45	0.012-0.03	3
Chinese cabbage	Japan	1-3	0.4-0.8	0.02	7
Citrus	Spain	2	0.48-1.2	0.021-0.03	14
Corn - see Maize					
Cucumber	Japan	1-3	0.5	0.02	1

Crop	Country	Application			PHI, days
		No	Rate, kg ai/ha	Spray conc., kg ai/hl	
Egg plant	Japan	1-3	0.4	0.02	1
	Spain	3-4	0.18-0.45	0.012-0.03	3
Grape	Japan	2	0.4-0.6	0.02	
Maize	Japan	1-4	0.5	0.02	7
Mandarin	Japan	1-3	1.0-1.6	0.02	14
Olive	Spain	1	0.075-0.11	0.0075-0.011	14
Onion	Japan	4	0.3	0.02	
Orange	Japan	1-3	1.0-1.6	0.02	14
Pea (young pods)	Japan	1-2	0.3	0.02	1
Peach	Japan	1-3	0.8	0.02	14
Pear	Japan	1-3	0.8-1.0	0.02	14
Persimmom	Japan	1-3	1.0	0.02	30
Pome fruit	Spain	2-3	0.32-0.45	0.02-0.03	14
Potato	Hungary	1-2	0.045-0.15	0.08-0.05	3
	Japan	1-3	0.3-0.6	0.02	14
	Poland	1	0.03-0.09	0.01-0.03	14
Radish (Japanese)	Japan	1-3	0.3	0.02	21
Rape	Poland	1	0.03-0.09	0.01-0.06	14
Rice	Japan	1-3	0.4	0.02	21
	Spain	1-2	0.15-0.23		14
Soya bean (young pods)	Japan	1-2	0.3	0.02	14
Sugar beet	Japan	1-3	0.3	0.02	14
Tea	Japan	1-2	0.4	0.02	7[1]
Tomato	Japan	1-2	0.4	0.02	1
	Spain	3-4	0.18-0.45	0.012-0.03	3
Wheat	Japan	1-2	0.4	0.02	14

[1]before picking

RESIDUES RESULTING FROM SUPERVISED TRIALS

Supervised trials were carried out on several types of crop in Japan by the manufacturer, Mitsui-Toatsa Chemicals Inc., and all trials were reported by the Japan Food Research Laboratories. References in the Tables to the trials in Japan all refer to the date of the reports evaluated. All trials on crops in Japan were carried out at two experimental stations but in the same year.

Trials were also carried out on apples and potatoes in Hungary at Plant Protection and Agricultural Stations, and on potatoes and rape in Poland by the Poznan Institute of Plant Protection.

In all experiments analyses were by methods which determined the parent compound and metabolites containing the 3-phenoxybenzyl moiety. In all experiments in Japan studies were carried out to determine the stabiltiy of residues of etofenprox in collected samples.

Results in the Tables are underlined when the treatment was in accordance or aproximately in accordance with the approved use and recommended withholding period in the country in which the trial was carried out.

Citrus fruits. The only trials on citrus fruits were carried out on mandarins in Japan and with the approved use and recommended pre-harvest interval. Residues were determined in pulp and peel, and the level of residues in the whole fruit was calculated. With a pre-harvest interval of 2 weeks residues were below the limit of determination in the pulp and 6.6-11.4 mg/kg in the peel, equivalent to 1.5-1.9 mg/kg in the whole fruit (Table 2).

Pome fruits. Field trials were carried out on apples in Hungary and Japan and in both countries with treatments in conformity with approved uses, which were quite different in the two countries. Residues in apples in Japan after treatment with 1.0-1.2 kg ai/ha and a PHI of 2 weeks were 0.4-0.8 mg/kg, and residues in apples from Hungary after treatment with 0.15 kg ai/ha and the same PHI were 0.1-0.2 mg/kg (Table 2).

Trials were carried out on pears in Japan with the approved use, 0.8-1.0 kg ai/ha, giving residues of 0.2-0.5 mg/kg (Table 2).

Peaches. Trials were carried out in Japan on peaches with the approved use (0.8 kg ai/ha). Residues were determined separately in the pulp and peel with no calculation of the residues in the whole fruit and no information about the ratio of the weight of the peel to that of the pulp. After 2 weeks residues were undetectable in the pulp and 3.7-6.8 mg/kg in the peel (Table 2).

Grapes. Residues in grapes from trials in Japan were from 0.6 to 4 mg/kg from applicatin at 0.4-0.6 kg ai/ha. No information was given about the recommended pre-harvest interval in Japan (Table 2).

Persimmons. Field trials were carried out in Japan on persimmons in conformity with the approved use. After 28 days, which is the recommended PHI in Japan, residues were 0.56-0.70 mg/kg (Table 2).

Vegetables except root and tuber vegetables. Field trials were carried out in Japan on onions, cabbage, cucumbers, egg plants, tomatoes, chinese cabbage, peas and soya beans, all in accordance with approved uses.

Residues in onions in trials with 4 applications at 0.3 kg ai/ha were all below the limit of determination (Table 3).

Residues in cabbages after treatment with 0.4-0.5 kg ai/ha

and the recommended PHI of 3 days were 0.21-0.32 mg/kg (Table 3).

Residues in cucumbers after treatment with 0.5 kg ai/ha and a PHI of 1 day were 0.12-13 mg/kg (Table 3).

Residues in egg plants after treatment with 0.4 kg ai/ha and a PHI of 1 day were 0.15-0.48 mg/kg (Table 3).

Residues in tomatoes after treatment with 0.4 kg ai/ha and a PHI of 1 day were 0.35-1.9 mg/kg (Table 3).

Residues in chinese cabbage after treatment with 0.4 and 0.8 kg ai/ha and a PHI of 7 days were 0.08-0.15 mg/kg (Table 3).

Residues in peas with pods after treatment with 0.3 kg ai/ha and a PHI of 1 day were 0.34-0.79 mg/kg (Table 3).

Residues in soya beans were determined in unripe and mature beans. Soya beans were treated with 0.3 kg ai/ha and residues after a pre-harvest interval of 14 days were 1.0-1.1 mg/kg in unripe beans and below the limit of determination in mature beans (Table 3).

Potatoes. Field trials on potatoes were carried out in Hungary, Japan and Poland, all at approved application rates, but only in Japan were samples taken at the recommended pre-harvest interval.

In Hungary potatoes were treated with 0.15 kg ai/ha and samples were taken 7 days and later after the last application, whereas the recommended PHI is 3 days. Residues were below the limit of determination (<0.05 mg/kg). In Japan residues after treatment with 0.3 and 0.6 kg ai/ha and a PHI of 14 days were below the limit of determination (<0.01 mg/kg). In Poland potatoes were treated with 0.03-0.09 kg ai/ha, and residues after 74 days were <0.01 mg/kg. In Poland residues were also determined in potato haulm after treatments at 0.06 and 0.09 kg ai/ha. Residues in the haulm were 0.86 and 1.6 mg/kg respectively (Table 3).

Japanese radishes. Trials were carried out in Japan in conformity with the approved uses at 0.4 and 0.8 kg ai/ha. Residues 7 days after the last application were 0.08-0.15 mg/kg. Residues in the leaves from the same treatments were 0.03-1.2 mg/kg (Table 3).

Sugar beet. Residues were determined in the roots and leaves of sugar beets after the approved treatment of 0.3 kg ai/ha. After 14 days residues in the roots were <0.01-0.04 mg/kg, and in the leaves 1.0-1.7 mg/kg (Table 3).

Rape. Treatments of rape were carried out in Poland with the approved uses of 0.03-0.09 kg ai/ha. The recommended pre-harvest interval in Poland is 14 days, but samples were taken only at 59 and 74 days after application. Residues in rape seed and straw from the same treatments were all <0.05 mg/kg (Table 4).

Rice. Trials were carried out in Japan with treatments according to the approved use. Residues in the grain 21 days after the last application were <0.01-0.30 mg/kg. Residues in the straw from the same treatments and PHI were 0.9-5.3 mg/kg (Table 5).

Wheat. Residues in grain from wheat treated in Japan in conformity with the approved use, 0.4 kg ai/ha, and the recommended PHI of 14 days were 0.01-0.13 mg/kg (Table 5).

Maize and sweet corn. In Japan trials were carried out with the same treatment of sweet corn and maize. The approved rate is 0.5 kg ai/ha and the recommended pre-harvest interval is 7 days. Residues in sweet corn and maize were all below the limit of determination (<0.01 mg/kg, Table 4).

Tea. Field trial were carried out in Japan on tea with the approved rate of 0.4 kg ai/ha. Samples of tea leaves were taken and dried. Residues were determined in the dried leaves and in drinking tea prepared from the dried leaves by adding 540 ml of boiling water to 9 g leaves and filtering after 5 minutes. Residues in the leaves and in tea from leaves harvested 7 days after the last application, which is the recommended PHI, were 16-69 and 0.06-0.52 mg/kg respectively (Table 6).

Table 2. Residues of etofenprox in fruits from supervised trials.

Crop	Application				PHI,	Residues, mg/kg	Re-port
Country Year	No	Intv. weeks	kg ai/ha	kg ai/hl	days		
Mandarin							
Japan 1986 (Shizuoka)	3	2	1.0	0.02	14 20 28	pulp peel fruit <0.01(2) 7.2-7.6 1.5 <0.01(2) 6.6-6.3 1.4 <0.01(2) 5.2-4.8 1.1	7.1 87
(Oita)	3	2	1.6	0.02	14 21 28	<0.01(2) 11.4(2) 1.9 <0.01(2) 9.6-9.1 1.8 <0.01(2) 7.6-7.3 1.4	7.1 87
Apple							
Hungary 1987 (Zalaegersz.)	2	4	0.15	0.015	0 1 4 8 12 19	0.12-0.16-0.08 0.08-0.12-0.06 0.10-0.17-0.09 0.07-0.04-0.11 0.08-0.13-0.03 0.04-0.02-0.02	24 1.2 1
(Tiszavasv.)	5	3-4	0.15	0.01	0 1 4 6 10 14	0.46-0.36-0.18 0.46-0.40-0.09 0.28-0.20-0.10 0.30-0.06-0.05 0.20-0.20-0.10 0.23-0.15-0.11	600
Japan 1983 (Nagano)	3	1	1.2	0.02	14 21 28	0.37-0.41 0.27-0.28 0.27-0.31	27.7 83
(Toyama)	3	1	1.0	0.02	14 21 28	0.79-0.82 0.69-0.70 0.54-0.59	27.7 83
Pear							
Japan 1983 (Akita)	3	1	0.8	0.02	14 21 27 41	0.23-0.23 0.20-0.22 0.21-0.22 0.18-0.20	27.7 83

Crop / Country Year	Application: No	Intv. weeks	kg ai/ha	kg ai/hl	PHI, days	Residues, mg/kg	Report
(Nagano)	3	1	1.0	0.02	14 21 28 42	0.52-0.53 0.43-0.49 0.29-0.30 0.15-0.17	27.7 83
Peach							
Japan 1984 (Yamanashi)	3	2	0.8	0.02	14 21 28	pulp / peel <0.01-<0.01 / 2.3-3.7 <0.01-<0.01 / 4.2-4.2 <0.01-<0.01 / 1.2-1.3	20.5 85
(Niigata)	3	1	0.8	0.02	7 14 21 28	0.01- 0.01 / 5.5-5.6 <0.01-<0.01 / 6.4-6.8 0.02- 0.03 / 5.3-5.8 0.02- 0.02 / 5.3-5.5	20.5 85
Grapes							
Japan 1985 (Yamanashi)	2	2	0.4	0.02	28 42 56	4.0-3.8 2.1-2.0 1.1-1.1	27.11 85
(Kyota)	2	2	0.6	0.02	28 42 56	2.7-2.6 0.90-0.90 0.66-0.64	27.11 85
Persimmon							
Japan 1984 (Nara)	3	2	1.0	0.02	21 28 42	0.73-0.75 0.56-0.62 0.43-0.45	20.5 85
(Tokushima)	3	2	1.0	0.02	20 27 42	1.1-1.2 0.67-0.70 0.57-0.57	20.5 85

Table 3. Residues of etofenprox in vegetables from supervised trials.

Crop / Country Year	Application: No	Intv. weeks	kg ai/ha	kg ai/hl	PHI, days	Residues, mg/kg	Report
Onion							
Japan 1989 (Ibaragi)	4	2	0.3	0.02	14 21	<0.01-<0.01 <0.01-<0.01	30.3 90
(Nagamo)	4	2	0.3	0.02	14 21	<0.01-<0.01 <0.01-<0.01	30.3 90
Cabbage							
Japan 1983 (Ibaragi)	3	1	0.4	0.02	3 7 14	0.30-0.32 0.14-0.16 0.09-0.09	27.7 84
(Kanagawa)	3	1	0.5	0.02	3 7 14	0.21-0.21 0.06-0.06 0.08-0.08	27.7 84
Cucumber							
Japan 1984 (Ibaragi)	3	1	0.5	0.02	1 3 7	0.12-0.13 0.04-0.04 0.03-0.03	20.5 85
(Saitama)	3	1	0.5	0.02	1 3 7	0.13-0.13 0.04-0.04 <0.01-<0.01	20.5 85
Egg plant							
Japan 1984 (Ibaraga)	3	1	0.4	0.02	1 3 7	0.48-0.48 0.40-0.42 0.13-0.14	20.5 85

Crop Country Year	Application No	Intv. weeks	kg ai/ha	kg ai/hl	PHI, days	Residues, mg/kg	Report
(Saitama)	3	1	0.4	0.02	1 3 7	0.15-0.17 0.09-0.09 0.02-0.02	20.5 85
Tomato							
Japan 1984 (Ibaraga)	3	1	0.4	0.02	1 3 7	0.35-0.36 0.34-0.37 0.31-0.32	20.5 85
(Nagano)	3	1	0.4	0.02	1 3 7	1.8-1.9 1.8-1.8 2.0-2.0	20.5 85
Chinese cabbage							
Japan 1983 (Tochigi)	3	1	0.4	0.02	7 14 22	0.08-0.08 0.02-0.02 0.01-0.01	27.7 84
(Nagano)	3	1	0.8	0.02	7 14 21	0.14-0.15 0.02-0.02 0.07-0.07	27.7 84
Peas with pods							
Japan 1990 (Wakayama)	2	2	0.3	0.02	1 7 14 21	0.35-0.34 0.05-0.04 <0.02-0.02 <0.02-0.02	30.3 90
(Hiroshima)	2	2	0.3	0.02	1 7 14 21	0.79-0.79 0.27-0.26 0.16-0.15 <0.02-<0.02	30.3 90
Soya bean							
Japan 1984 (Fukushima)	2	1	0.3	0.02	7 14 21	unripe mature 1.6-1.7 1.1-1.1 <0.01 (2) 0.26-0.27	30.3 85
(Nagano)	2	1	0.3	0.02	7 14 21	1.5-1.5 1.0-1.0 <0.01 (2) 0.18-0.20	30.3 85
Potato							
Hungary 1981 (Gavavenc)	1		0.15	0.025	7	<0.05 (5)	602
(Nyiregyháza)	1		0.15	0.025	7	<0.05 (5)	
(Aranykalász)	2	6.5	0.15	0.05	27[1] 39[2]	<0.01 (3) [1] after 1 appl. <0.01 (7) [2] after last appl.	
Japan 1984 (Hokkaido)	3	1	0.3	0.02	3 7 14	<0.01-<0.01 <0-01-<0.01 <0.01-<0.01	20.5 85
(Nagano)	3	1	0.6	0.02	3 7 14	<0.01-<0.01 <0.01-<0.01 <0.01-<0.01	20.5 85
Poland 1986	1		0.03 0.045 0.06 0.09	0.01 0.015 0.02 0.03	74 74 74 74	tuber haulm <0.01 <0.01 <0.01 0.86 <0.01 1.6	17. 12. 86
Japanese radish							

Japan 1987						roots leaves	
(Nagano)	3	1.5	0.3	0.02	14	<0.01 (2) 0.33-0.31	1.6.
					21	<0.01 (2) 0.03 (2)	88
					30	0.01 (2) 0.03 (2)	
(Ishikawa)	3	1.5	0.3	0.02	14	0.05 (2) 2.0-1.8	1.6.
					21	0.03 (2) 1.2-1.1	88
					30	<0.01 (2) 0.3 (2)	
Sugar beet							
Japan 1984						roots leaves	
(Sapporo)	3	2	0.3	0.02	14	<0.01 (2) 1.6-1.7	20.5
					21	<0.01 (2) 0.91-0.97	85
					28	<0.01 (2) 0.38-0.43	
(Naganuma)	3	2	0.3	0.02	14	0.04 (2) 1.0-1.1	20.5
					21	0.03 (2) 0.36-0.36	85
					28	0.04 (2) 0.31-0.31	

Table 4. Residues of etofenprox in rape seed from supervised trials in Poland in 1986.

	Application				PHI,	Residues, mg/kg		Report
Poland	No	Intv. weeks	kg ai/ha	kg ai/hl	days			
(Trzebnica)						seed	straw	
	1		0.03	0.01	74	<0.05	<0.05	21.3
			0.045	0.015	74	<0.05	<0.05	87
			o.o6	0.02	74	<0.05	<0.05	
			0.09	0.03	74	<0.05	<0.05	
(Winnogora)								
	1		0.03	0.01	59	<0.05	<0.05	21.3
			0.045	0.015	59	<0.05	<0.05	87
			0.06	0.02	59	<0.05	<0.05	
			0.09	0.03	59	<0.05	<0.05	

Table 5. Residues of etofenprox in cereal grains from supervised trials.

Crop	Application				PHI,	Residues, mg/kg		Report
Country Year	No	Intv. weeks	kg ai/ha	kg ai/hl	days			
Rice								
Japan 1986						grains	straw	
(Chiba)	5	2	0.4	0.02	14	0.30-0.29	3.1-3.0	7.1.
					21	0.30-0.30	5.3-5.1	87
					28	0.06-0.05	2.5-2.4	
(Ishikawa)	5	2	0.4	0.02	14	0.02-0.02	2.0-1.9	
					21	<0.01-<0.01	0.9-0.9	7.1.
					28	<0.01-<0.01	1.4-1.3	87
Wheat								
Japan 1987								
(Chiba)	2	2	0.4	0.02	14	0.01-0.01		23.5
					21	<0.01-<0.01		88
					28	<0.01-<0.01		
(Ishikawa)	2	2	0.4	0.02	14	0.13-0.12		23.5
					21	0.06-0.06		88
					28	0.01-0.01		
Maize and sweet corn								
Japan 1984						Maize	Sweet corn	
Ibaragi	4	2	0.5	0.02	7	<0.01 (2)	<0.01 (2)	20.5
					14	<0.01 (2)	<0.01 (2)	85
Nagano	4	2	0.5	0.02	7	<0.01 (2)	0.06 (2)	20.5
					14	<0.01 (2)	<0.01-0.01	85

Table 6. Residues of etofenprox in tea from supervised trials in Japan in 1983.

Region	Application				PHI,	Residues, mg/kg	Report
	No	Intv. weeks	kg ai/ha	kg ai/hl	days		
Saga	2	1	0.4	0.02	7 14 21	tea leaves drinking tea 16-17 0.06-0.07 10-10 0.03-0.04 1.5-1.5 <0.01 (2)	7.1.87
Kagoshima	2	1	0.4	0.02	7 14 21	66-69 0.51-0.52 20-20 0.13-0.14 3.4-3.8 0.02 (2)	7.1.87

Animal feeding studies

Dairy cows were fed diets containing 10, 30 and 1000 mg etofenprox/animal/day for 28 days, the compound being incorporated with the concentrate feed. The dosage of 1000 mg/day represents a considerably higher level of intake than would occur in practice. Milk samples were taken from the daily production from 3 days before dosing until the end of the dosing period of 28 days. Samples were also taken from the group given 1000 mg/day during a withdrawal period of 14 days, so that the last milk sample from this group was taken at day 42. The cows fed with 10 and 30 mg/day and 3 cows fed with 1000 mg/day were slaughtered after 29-30 days, while 2 cows fed with 1000 mg/day were killed 14 days later at day 43. Samples of liver, kidney, skeletal muscle, peritoneal fat and subcutaneous fat were analyzed.

Residues in milk. Residues in the milk from cows fed with 10 and 30 mg/day were all below the limit of determination (<0.05 mg/kg) except 2 samples from one cow fed with 30 mg/kg, where the residues were at the limit of determination. Residues in the milk from cows fed 1000 mg/day were from 0.66 to 2.1 mg/kg during the dosing period, and from 1.66 to 0.09 mg/kg during the no-treatment withdrawal period, declining rapidly during the early part of this period but with the rate slowing over the last part (Table 7).

Residues in tissues. Residues of etofenprox in liver, kidney, and skeletal muscle from cows fed with 10 and 30 mg/day were all below or at the limit of determination (0.05 mg/kg), but were present in peritoneal and subcutaneous fat up to 1.9 mg/kg. Residues in cows fed with 1000 mg/kg and slaughtered at days 29-31 were present in liver (0.25-0.63 mg/kg), kidney (0.08-0.62 mg/kg), muscle (0.08-0.35 mg/kg), peritoneal fat (1.7-14 mg/kg) and subcutaneous fat (1.0-3.5 mg/kg). After a 14-day withdrawal period residues were still detectable in all tissues, at the same levels in peritoneal and subcutaneous fat but with some reduction in the liver, kidney and muscle (Roberts *et al.*, 1987). (Table 8).

Table 7. Residues of etofenprox in milk of cows.

Days	mg/l milk		
	Feeding level, mg etofenprox/cow/day		
	10	30	1000
2-28	<0.05-<0.05	<0.05-0.05	0.66-2.1 mean: 1.3
30-32			0.31-1.7
34-36			0.14-0.25
38-40			0.10-0.22
42			0.09-0.10

Table 8. Residues of etofenprox in tissues of cows.

Feeding level, mg/cow/day	mg/kg tissue at day 29-30				
	Liver	Kidney	Skeletal muscle	Peritoneal fat	Subcutaneous fat
10	<0.05-<0.05	<0.05-<0.05	<0.05-<0.05	0.21-0.54	0.08-0.28
30	<0.05-<0.05	<0.05-0.05	<0.05-0.05	0.84-2.0	0.07-0.50
1000	0.25-0.63	0.08-0.16	0.08-0.35	1.8-14	1.0-3.5
1000 (day 42)	<0.05-0.05	0.23-0.23	0.05-0.05	4.2-12	0.33-3.0

FATE OF RESIDUES

General

The fate of etofenprox was studied in plants (beans and rice), soil and water. The metabolic pathways of etofenprox in animals were also proposed, but with references only in the toxicological information available to the Meeting.

Etofenprox is mainly metabolized by desethylation of the ethoxyphenyl group, hydroxylation of the phenoxy ring and oxidation of the benzyl moiety with subsequent cleavage of the ether linkage to form polar compounds, and in animals to form conjugates.

In animals

According to the summarized information avilable to the Meeting etofenprox was rapidly excreted when given to male and female rats, with more than 80% of the administered dose excreted within 48 hours in faeces and urine and with the major route via faeces. The compound was metabolized by desethylation of the ethoxyphenyl group, hydroxylation of the phenoxy ring and oxidation of the benzyl methylene group. The same metabolic

pattern and a similar profile of metabolites were observed in dogs. Proposed metabolic pathways of etofenprox in animals are shown in Figure 1.

In plants

Beans. A study was carried out by applying [^{14}C]etofenprox to bean leaves under laboratory conditions. Two radiolabelled compounds were used: [á-^{14}C]etofenprox, where the labelled carbon was in the benzyl methylene group and [1-^{14}C]propyl-etofenprox where one propyl carbon was labelled. Two primary leaves of the plant were treated with the labelled preparations and treated plants were harvested 1, 2 and 3 weeks after application and divided into treated leaves, other leaves, shoots and roots. The parent compound and its metabolites were identified using three different TLC systems, and the identity of each fraction was confirmed by co-chromatography with unlabelled compounds. The determination of the quantity of the parent compound and the metabolites was carried out by radioanalysis using X-ray film.

The radioactivity in and on the treated leaves decreased with time, but that in other parts of the plants (leaves, shoots and roots) was less than 1% of the total radioactivity. After 3 weeks the parent compound amounted to 0.26% in the other leaves and shoots and to 0.015% in the roots. No significant difference between the two labelled forms was found in the proportion of metabolites after 1 and 3 weeks. Etofenprox was gradually decomposed to less than 75% of the original quantity after 1 week and to less than 50% after 3 weeks. The main metabolite was 2-(4-ethoxyphenyl)-2-methylpropyl 3-phenoxybenzoate (compound IV, Figure 2), which was present at 8% after 1 week and 13% after 3 weeks. Residues of the more polar metabolites (mainly 3-phenoxybenzoic acid and 2-(4-ethoxyphenyl)-2-methylpropan-1-ol) were increased after 3 weeks.

The half-life of etofenprox on bean leaves was determined to be 3 weeks with both labelled forms. At that time the main metabolite (IV) accounted for 11-15% and unrecovered compounds for 14-18% of the radioactivity. Figure 2
shows the proposed pathways, which are mainly oxidation at both carbons of the ether linkage, desethylation and acetylation, dephenylation of the phenoxy group and *para*-hydroxylation of the phenoxy group. Some of the more polar metabolites were conjugated with glucose.

Experiments have shown that all metabolites except the conjugates are very similar to photodegradation products, implying that the formation of these metabolites is probably affected by light (Tomoda *et al.*, 1985b).

Rice. A similar study to that on bean plants was carried out on rice. The experimental conditions were the same except that seeds from the rice were also investigated. The half-life of etofenprox on rice plants was determined to be 1 week, which is less than on beans, and after 20 days 90% of the original etofenprox was degraded. As with beans very little radioactivity was transferred to other parts of the plant. Residues of the parent compound in seeds after 2, 4 and 6 weeks were beween 0.01

and 0.04% of the radioactivity in the plant. The degradation pathways were very similar to those in bean plants (Tomoda *et al.*, 1985a).

In soil

Laboratory studies. Three experiments were carried out on the degradation of etofenprox in soil under laboratory conditions. Three different types of soil were used: Yamanashi sandy soil containing 78% sand, 11% silt and 11% clay; Chiba light clay containing 28% sand, 39% silt and 32% clay; and Shizuoka light clay containing 43% sand, 26% silt and 31% clay. The same two labelled compounds that were used in the degradation studies on plants were applied to the soils.

In one experiment samples of the three soil types were pre-incubated for 2 weeks, ^{14}C-labelled etofenprox was added and the incubation continued at 25°C in the dark, and the moisture content was maintained. Soil samples were extracted and analyzed after the incubation. The total radioactivity decreased gradually, and 2 weeks after application it amounted to 60-70% of the original. The half-life of etofenprox in soil was determnined to be 6-9 days with only small differences between soil types or the position of labelling. The amount of etofenprox decreased to 15% after 3 weeks. Etofenprox was degraded mainly by oxidation to 2-(4-ethoxyphenyl)-2-methylpropyl 3-phenoxybenzoate and to 2-(4-ethoxyphenyl)-2-methylpropyl 3-hydroxybenzyl ether (Figure 3).

The proportions of these products were 2.6-7.1% and 1.4-4.0% of the radioactivity, respectively, after 1 week and 1.4-4.2% and 1.3-3.0% after 2 weeks. Other, mainly polar products were present in minor quantities. The ^{14}C bound in the soil increased with time and was 25-44% 2 weeks after application.

Figure 1. Proposed metabolic pathways of etofenprox in animals.

*Postulated intermidiate

Figure 2. Proposed metabolic pathways of etofenprox in plants.

*Postulated intermidiate

Figure 3. Proposed degradation pathways of etofenprox in soil.

In the second experiment the liberation of $^{14}CO_2$ was determined. Chiba light clay was incubated with etofenprox at 25◦C in the dark. The evolved $^{14}CO_2$ was trapped, and residues of the parent compound and degradation products were determined. After 2 weeks 8-12% of the radioactivity was present as $^{14}CO_2$, and after 8 weeks the figure was 32-44%.

In the third experiment the influence of micro-organisms was investigated. The two ^{14}C-labelled forms of etofenprox were applied to sterilized and non-sterilized Yamanashi sandy loam samples, which were incubated at 25◦C for 2 weeks under light and dark conditions. After 2 weeks 60-80% of the applied etofenprox had been decomposed in the unsterilized soil, both in darkness and in light, but no degradation occurred in the sterilized samples (Tomoda *et al*., 1985c).

Field studies. The rate of degradation of etofenprox was examined in paddy and upland soils. In the paddy soil experiment two soil types were used: loam with 8.2% clay and 7.5% organic carbon and clayish loam with 21% clay and 2.4% organic carbon. Etofenprox was applied at the rate of 0.4 kg ai/ha and 7 days later at 0.9 kg ai/ha. Samples were taken from the upper 10 cm of the soil 0, 1, 3, 7, 14, 28, 56 and 98 or 105 days after the second application. The half-life was determined to be approximately 79 days in loam soil and 62 days in clayish loam (Ishii *et al*., 1985a).

The investigation on upland soil was carried out with volcanic ash loam containing 10% clay and 6.2% organic carbon, and alluvial clayish loam containing 2% clay and 2.8% organic carbon. Etofenprox was applied 3 times at the rate of 0.16-0.20 kg or 0.5 kg ai/ha. Samples were taken 0, 1, 3, 7, 14, 28 and 56 days after the last application. The half-life was determined to be 39 days in volcanic ash loam and only 9 days in alluvial clay loam (Ishii *et al*, 1985b).

Adsorption and leaching. The adsorption and leaching of etofenprox was studied in three soil types: Yamanashi sandy loam, Chiba light clay and Shizuoka light clay (the compositions were given in "Laboratory studies"). Both [1-^{14}C]propyl- and [á-^{14}C]benzyl-labelled etofenprox were used. In two experiments glass columns were packed with soil, incubated for 2 weeks at 25◦C in darkness, and labelled etofenprox mixed with soil was applied as a 5 cm layer at the top of the columns. In one experiment the two labelled compounds were mixed with the soil just before applications to the columns, in the other the soil was treated and pre-incubated 2 weeks before application. The columns were eluted gently with water equivalent to 3-5 times the maximum water-holding capacity of each soil.

In the experiment where the soil was treated just before application to the columns approximately 74% of the radoactivity remained in the top 5 cm layer, and the parent compound accounted for most of it. Translocation was very low, and unchanged parent compound was not detected in the deeper layers. In the experiment with pre-incubated soil at least 90% of the radioactivity remained in the top 5 cm layer. The radioactivity

recovered from eluted solutions was less than 4 and 5% of the applied radioactivity for direct-packed and pre-incubated soils respectively, and unchanged parent compound was not detected in the eluates (Tomoda *et al.*, 1985d).

In water

The stability of etofenprox in water was investigated under laboratory conditions at various pH values in darkness at 25◦C. Etofenprox was stable under neutral (pH 7.0) and acidic (pH 5.0) conditions. The estimated half-life was more than one year in the range of pH values tested (Asari, 1992).

In another experiment 200 mg etofenprox/l city water was incubated in a beaker covered with polythene in a greenhouse at 23 ± 5◦C. After 1 and 3 weeks 70% and 93% of the etofenprox had decomposed. This relatively rapid degradation compared with the degradation under laboratory conditions was mainly due to sunlight (Udagawa *et al.*, 1986).

Photodegradation

The half-life and degradation pathways of [1-^{14}C]propyl- and [á-^{14}C]benzyl-labelled etofenprox on the surface of glass discs were studied. The compound was exposed to artificial light of 30,000 lux for 13 hours per day at 25-30◦C. The half-life was approximately 4 days and the major degradation product was 2-(4-ethoxyphenyl)-2-methylpropyl 3-phenoxybenzoate, which accounted for 25% of the radioactivity after 7 days of exposure. The degradation pathways did not show any differences from those observed in the metabolism study on bean leaves. The degradation which occurred on the surface of bean leaves was therefore considered to be strongly linked to photodegradation.

The degradation of etofenprox applied as a film to the bottom of a silica flask was also studied. The compound was exposed to high-intensity light from a xenon lamp (550 ìw/cm^2) for about 10 hours. Several degradation products were identified, including the main product found in the experiment with glass discs (Tomoda *et al.* 1985e).

METHODS OF RESIDUE ANALYSIS

Methods have been developed to determine etofenprox in plant material, soil milk and animal tissues.

The same method with some modifications is used for plant material and soil. Residues are extracted with acetone and the extract is cleaned up by partition between n-hexane and water. Crop extracts are further cleaned up by Florisil column chromatography and soil extracts by column chromatogrphy on alumina and silica gel. For some crops it is possible to analyse the chromatographed extract directly for residues. In most cases the purified extract is reacted with trimethylsilyl iodide to form 3-phenoxybenzyl iodide and the reaction mixture partitioned with n-hexane. The derivative is determined by GLC with an EC

detector. The limit of determination is in the range of 0.01-0.02 mg/kg. The recovery is more than 73%.

Residues in milk and animal tissues are extracted into ethyl acetate/hexane. The solvent is removed by rotary evaporation and the residue cleaned up by Florisil chromatography. The concentrated eluate is derivatized with trimethylsilyl iodide to form 3-phenoxybenzyl iodide, which is cleaned up on a silica "Sep-pak" and determined by GLC with an EC detector. The limit of determination is 0.05 mg/kg.

NATIONAL MAXIMUM RESIDUE LIMITS

National MRLs reported to the Meeting are shown below.

Country	Crop	MRL, mg/kg
Italy	Apple	0.23
	Cabbage	0.96
	Egg plant	<0.05
	Peach	0,16
	Tomato	0.23
Hungary	Apple	1
	Cereals	0.1
	Corn	0.05
	Grape	5

Japan	Apple	2
	Azuki beans	0.1
	Cabbage	2
	Cereals	0.5
	Chestnut	2
	Chinese cabbage	2
	Citrus (pulp)	2
	Citrus (peel)	10
	Cucumber	2
	Egg plant	0.2
	Lettuce	2
	Melon	2
	Pea, podded	2
	Peach	2
	Pear	2
	Persimmom	2
	Potato	0.1
	Radish, Japanese	2
	Rice grains (unpolished)	0.5
	Soya beans	0.1
	Soya beans (prematured)	2
	Sugar beets	0.5
	Sweet potato	0.1
	Tea leaves (open field)	10
	Tea leaves (under coverage)	10
	Tomato	0.5
	Water melon	2
	Welsh onion	2
Spain	Cabbage	0.2
	Citrus	1
	Egg plant	0.2
	Fruit trees	1
	Rice	1
	Tomato	0.5

APPRAISAL

Degradation studies were carried out on etofenprox in plants (beans and rice) and soil. Metabolic studies were also carried out in animals (rats and dogs), but information about these was only available to the Meeting in a summarized form.

The metabolism of etofenprox in bean and rice plants was examined by applying á-^{14}C-benzyl-labelled and 1-^{14}C-propyl-labelled etofenprox to leaves of the plants under laboratory conditions. There was very limited translocation of the parent compound and its metabolites to other parts of the plants, including the seeds in rice. Etofenprox was gradually decomposed on and in the treated leaves and was reduced to approximately 50% after 3 weeks. The main metabolite from the oxidization of etofenprox was 2-(4-ethoxyphenyl)-2-methylpropyl 3-phenoxybenzoate. Residues of other metabolites, mainly 3-phenoxybenzoic acid and 2-(4-ethoxyphenyl)-2-methylpropan-1-ol, were also present but in small quantities. The half-life of etofenprox on beans was determined to be 3 weeks for both labelled forms. At that time the main metabolite accounted for 11-15% and unrecovered compounds for 14-18% of the radioactivity applied. Experiments have shown that all metabolites observed on the bean leaves, except conjugates, were very similar to products formed by photodegradation, implying that the metabolism on plant leaves is affected by light.

Degradation studies on etofenprox in soil were carried out with three different soil types using the same two ^{14}C-labelled forms as in the experiments on plants. The half-life of etofenprox in soil was determined to be 6-9 days and largely independent of the soil types and labelled forms used. The main products formed after oxidation were 2-(4-ethoxyphenyl)-2-methylpropyl 3-phenoxybenzoate and 2-(4-ethoxyphenyl)-2-methylpropyl 3-hydroxybenzyl ether. The liberation of $^{14}CO_2$ from the degradation of ^{14}C-labelled etofenprox was examined. After 2 and 8 weeks the radioactivity originating from CO_2 was 8-12 and 32-44%, respectively. The degradation of etofenprox in soil was evidently caused by micro-organisms as no degradation occurred in sterilized soil.

Field studies were carried out to examine the rate of degradation of etofenprox in paddy and upland soils. The half-lives in the two paddy soil types examined were 79 and 62 days, while the half-lives in the two upland soils were 39 and 9 days. Etofenprox is strongly adsorbed to soil, and little leaching takes place. No residues of the parent compound and only small quantities of metabolites were detectable in the effluents from three soil types after 2 weeks of leaching.

Supervised trials were carried out on several kinds of fruits and vegetables in Japan, on apples and potatoes in Hungary, and on potatoes and rape in Poland. In Japan trials were also carried out on rice, wheat, corn and tea. The application rates were different in the three countries. In Japan the rates were generally of the order of 0.5-1.5 kg/ha,

while the highest rate in Hungary was 0.15 kg ai/ha and in Poland 0.09 kg ai/ha. Residues in apples were 0.4-0.8 mg/kg in Japan and 0.1-0.2 mg/kg in Hungary. Residues in potatoes were below the limit of determination in all the trials, including those in Japan at the highest dose rate.

Residues were determined in animal products after feeding experiments on dairy cows. Cows were fed with etofenprox at levels of 10, 30 and 1000 mg/animal/day, where 1000 mg/day represents a considerably higher level of intake than would occur in practice. After a feeding period of 28 days residues in milk from cows fed with 10 and 30 mg/day were at or below the limit of determination (0.05 mg/kg), but residues from 1000 mg/day were up to 2 mg/kg. Residues in tissues were also examined after the feeding period. Residues in liver, kidney and skeletal muscle from 10 and 30 mg/day were at or below the limit of determination, but in the peritoneal and subcutaneous fat were quite high and up to 0.84 mg/kg. For cows fed with 1000 mg/day, residues were up to 14 mg/kg in peritoneal fat and up to 3.5 mg/kg in subcutaneous fat, and were also present in kidney, liver and muscle.

Residues of etofenprox in plant material and soil are determined by gas chromatography with an electron capture detector after extraction with acetone and clean-up by partitioning with water/n-hexane and by column chromatography on Florisil or alumina/silica gel. For most crops and soil the purified extract is reacted with trimethylsilyl iodide to form 3-phenoxybenzyl iodide. The limit of determination is 0.01 mg/kg. For milk and animal tissues the method is similar, but ethyl acetate/hexane is used for the extraction and a silica sep-pak is used for the chromatographic clean-up. The limit of determination for residues in animal products is 0.05 mg/kg.

The manufacturer informed the Meeting that the analytical methods described, including the chromatographic clean-up step, are specific for the parent compound etofenprox and do not determine other compounds containing the 3-phenoxybenzyl moiety.

Supervised trials for most crops were carried out in only one country, Japan, and although they were at two sites they took place within the same year. The Meeting was therefore able to propose maximum residue limits for etofenprox in only two crops.

RECOMMENDATIONS

On the basis of the data on residues from supervised trials the Meeting concluded that the residue levels listed below are suitable for establishing maximum residue limits.

Definition of the residue: etofenprox (fat-soluble).

Commodity	Recommended MRL (mg/kg)	PHI on which based, days

CCN	Name		
FP 0009	Pome fruits	1	14
VR 0859	Potato	0.01*	14

FURTHER WORK OR INFORMATION

Desirable

1. Submission of documentation for the specificity of the analytical methods for the determination of etofenprox.

2. Supervised trials on crops from more than one year and trials carried out in more than one country.

3. Studies on the processing of crops containing residues of etofenprox

4. Residues in straw from wheat and other crops used as animal feedingstuffs.

REFERENCES

(All unpublished reports)

1. Asari, K. 1992. Stability of etofenprox in water. Report from Mitsui-Toatsu Chemicals, Inc.

2. Ishii, M. *et al.*, 1985a. Residue Determination in Paddy Soil treated with Ethofenprox 20% E C and 1.5% G. Japan Analytical Chemistry Consult. Co. Ltd.

3. Ishii, M. *et al.*, 1985b. Residue Determination in Upland Soil treated with Ethofenprox 20% Wettable Powder. Japan Analytical Chemistry Consult. Co. Ltd.

4. Roberts, N.L., Cameron, D.M., Emerson, E.S. and Carter, J.N. 1987. Residues of Ethofenprox in the Milk and Tissues of Dairy Cows. Huntingdon Research Centre Ltd. Rep. MTC 132/87587.

5. Tomoda, K. *et al.*, 1985a. Metabolism Study of Ethofenprox-2. Meabolism in Rice Plants. Mitsui-Toatsu Chemicals, Inc.

6. Tomoda, K. *et al.*, 1985b. Metabolism Study of Ethofenprox-1. Meabolism in Bean Plants. Mitsui-Toatsu Chemicals, Inc.

7. Tomoda, K. *et al.*, 1985c. Metabolism Study of Ethofenprox-3. Meabolism in Soil. Mitsui-Toatsu Chemicals, Inc.

8. Tomoda, K. *et al.*, 1985d. Metabolism Study of Ethofenprox-4. Soil Leaching Test. Mitsui-Toatsu Chemicals, Inc.

9. Tomoda, K. *et al.*, 1985e. Metabolism Study of Ethofenprox- 5. Photodegradation on Glass Surface. Mitsui-Toatsu Chemicals, Inc.

10. Udagawa, T. *et al.*, 1986. Degradation of Ethofenprox in Water. Mitsui-Toatsu Chemicals, Inc.