Sugar beet. In a sugar beet processing study in the USA (Stearns, 1986d) Furadan 15G at 4.5 kg ai/ha was applied once to the soil in an 18-cm band at planting in Colorado in 1985. The beets were harvested 176 days after application and samples were analysed by the method of Barros. Limits of determination of 0.05 mg/kg were demonstrated for carbofuran and each metabolite by the analysis of fortified controls. The recoveries at 0.05 mg/kg (single samples) were carbofuran 84%, 3-keto-carbofuran 84%, 3-hydroxy-carbofuran 92%, 7-phenol 56%, 3-keto-7-phenol 100%, and 3-hydroxy-7-phenol 100%. The recovery of the 7-phenol was improved at 0.10 mg/kg to 66%. No carbofuran or metabolite was detected in any sample, where the limit of detection was estimated to be 0.01 mg/kg for the carbamates and 0.02 mg/kg for the phenols. Representative chromatograms were provided.

The beets were commercially processed into cossettes, dehydrated pulp, molasses and sugar. The analysis of fortified controls showed a limit of determination of 0.05 mg/kg for each analyte in each type of sample. The minimum recovery was 62% (7-phenol in sugar) and the maximum 138% (3-keto-7-phenol in molasses). Carbamates and phenols were undetectable (<0.01 mg/kg carbamates, <0.02 mg/kg phenols) in cossettes and dehydrated pulp. The 3-keto-7-phenol was detected in molasses and sugar at an estimated concentration of 0.03 mg/kg. A concentration factor could not be calculated as the raw commodity did not have detectable residues.

Potatoes. In a processing study in the USA (Shevchuk, 1995b) Furadan 4F was applied to a plot in Washington State in 1993, one in-furrow at planting (6.7 kg ai/ha, 36 g/l) and three times as a broadcast spray post-emergence at 2.2 kg ai/ha, 12 g/l. The total application was 13.4 kg ai/ha, twice the GAP rate. The PHI was 21 days. The potatoes were processed in a laboratory-scale simulation of commercial processes into chips and granules (dehydrated potatoes). Samples of tubers, chips, granules, wet peel and dry peel were analysed by the method of Barros, with limits of determination and detection of 0.05 and 0.01 mg/kg for each analyte in each commodity. The limit of detection was corroborated by sample chromatograms. The results are shown in Table 58. The phenol metabolites were concentrated 1.7 times in potato chips and 5 times in both granules and dry peel. Processing factors could not be calculated for the carbamates, because none of the samples contained quantifiable levels.

Table 58. Carbofuran and metabolites in or on processed potato products after treatment of a Washington potato plot at 13.4 kg ai/ha.

Sample	Residue, mg/kg					
	Carbofuran	3-K-CF	3-OH-CF	7-Phenol	3-K 7-P	3-OH-7-P
Tubers	<0.05	<0.05	<0.05	<0.05 (0.03)	<0.05	<0.05
Chips	<0.05	<0.05	<0.05	0.05	<0.05	<0.05 (0.01)
Granules	<0.05	<0.05	<0.05	0.14	(0.01)	<0.05 (0.02)
Wet peel	<0.05	<0.05	<0.05	<0.05 (0.02)	<0.05	<0.05
Dry peel	<0.05	<0.05	<0.05	0.12	<0.05 (0.02)	<0.05 (0.03)

Maize. A processing study on field corn (maize) was reported from the USA (Schreier, 1990b). A plot in Illinois was treated with Furadan 15G in-furrow at planting at 4.4 kg ai/ha. This was followed by one foliar treatment at the whorl stage with Furadan 15G at 3.4 kg ai/ha and two applications of

Furadan 4F at 3.4 kg ai/ha, a total application of 15 kg ai/ha (3 times the GAP rate); PHI was 42 days. The maize was processed by both wet and dry milling procedures and residues were determined in grain, grits, meal, flour, crude oil and refined (edible) oil after dry milling, and in starch, crude oil and refined oil after wet milling. Maize and the dry (non-oily) products were analysed for carbamates by the GLC method of Schreier with an NPD. The method of Leppert with GC-MS was used for the determination of carbamates and phenols in oils and of phenols in dry products. The limit of determination for each analyte in each commodity was shown to be 0.03 mg/kg by the analysis of fortified control samples and the limit of detection was estimated to be 0.01 mg/kg. The recoveries from fortified control samples and the results of the trial are shown in Table 59. No concentration of carbofuran or its metabolites was found in any processed fraction.

Table 59. Carbofuran and metabolites in or on maize and its milling fractions after treatment of a corn field with Furadan 15G and 4F at a total rate of 15 kg ai/ha, PHI 43 days. Illinois, USA.

Sample	Residue, mg/kg Recovery from controls fortified at 0.03 mg/kg					
	Carbofuran	3-K-CF	3-OH-CF	7-Phenol	3-K-7-P	3-OH-7-P
Grain	<0.03 103	<0.03 109	<0.03 109	<0.03 (0.01) 84	<0.03 90	<0.03 (0.03) 77
Dry Milling						
Medium Grits	<0.03 99	<0.03 93	<0.03 94	<0.03 69	<0.03 67	<0.03 (0.02) 62
Meal	<0.03 79	<0.03 104	<0.03 83	<0.03 96	<0.03 98	<0.03 (0.01) 85
Flour	<0.03 115	<0.03 117	<0.03 81	<0.03 60	<0.03 61	<0.03 (0.01) 60
Crude Oil	<0.03 61	<0.03 98	<0.03 96	<0.03 52	<0.03 91	<0.03 91
Refined oil	<0.03 68	<0.03 92	<0.03 63	<0.03 64	<0.03 84	<0.03 76
Wet Milling						
Starch	<0.03 97	<0.03 105	<0.03 76	<0.03 67	<0.03 70	<0.03 66
Crude Oil	<0.03 75	<0.03 99	<0.03 93	<0.03 71	<0.03 96	<0.03 101
Refined oil	<0.03 91	<0.03 111	<0.03 91	<0.03 63	<0.03 89	<0.03 80

In a second processing study (wet milling only) in the USA (Brooks and Arabinick, 1995) Furadan 4F was applied to maize in Iowa in 1994 at planting in-furrow at 4.4 kg ai/ha (81 g/l), at the whorl stage at 3.4 kg ai/ha (32 g/l), and as two broadcast foliar applications, each at 3.4 kg ai/ha (20 g/l). The total application was 15 kg ai/ha (3 times the GAP rate) and the PHI was 67 days. The residues in mature corn and starch were determined by the method of Barros, with limits of determination established at 0.03 mg/kg by the analysis of fortified controls. Recoveries from grain ranged from 72% (0.03 mg/kg 3-hydroxy-7-phenol) to 105% (0.03 mg/kg 3-hydroxy-carbofuran), and from starch from 68% (0.03 mg/kg 7-phenol to 123%; 0.03 mg/kg 3-hydroxy-7-phenol). The grain was found to contain detectable amounts of 3-hydroxy-carbofuran (estimated at 0.01 mg/kg) and quantifiable amounts of 3-hydroxy-7-phenol, 0.03 mg/kg. The starch contained no detectable residues, with the limit of detection estimated to be 0.01 mg/kg for each analyte. Carbamate residues were reduced in processing maize to starch, but a factor could not be determined.

Rice. A processing study was conducted in the USA (Shevchuk, 1995a). Rice in an Arkansas field was treated with Furadan 3G at 3.4 kg ai/ha (5 times the GAP rate) on the first day of permanent flooding, or about one month after planting. Mature rice was harvested 110 days after the treatment and processed by a batch procedure that closely followed standard commercial practice into polished rice, hulls and bran. The treated rough rice (110 kg) was dried (105 kg), aspirated and screened, yielding 23 kg of rough rice. This was dehulled and separated into hulls (3.9 kg), brown rice (18 kg) and unhulled rice (0.41 kg). The brown rice was debranned, yielding bran (2.4 kg) and white milled rice (16 kg). The rough rice and the processed fractions were analysed by the method of Barros. Duplicate control samples fortified at 0.03 mg/kg were analysed to establish the limits of determination. The lowest recovery was 62% for carbofuran in hulls and the highest 124% for 3-hydroxy-7-phenol in grain. Treated grain contained detectable amounts of 3-hydroxy-carbofuran (0.02 mg/kg) and the 3-hydroxy-7-phenol (0.02 mg/kg) and a quantifiable amount of the 7-phenol (0.05 mg/kg). Polished rice contained no detectable residues. Bran contained detectable levels of 3-keto-7-phenol (0.02 mg/kg, 2-fold concentration) and quantifiable levels of 7-phenol (0.42 mg/kg, 8-fold concentration) and 3-hydroxy-7-phenol (0.04 mg/kg, 2-fold concentration). Hulls contained quantifiable concentrations of carbofuran (0.02 mg/kg, 2-fold concentration), 3-keto-carbofuran (0.02 mg/kg, 2-fold concentration), 3-hydroxy-carbofuran (0.05 mg/kg, 4-fold concentration), 7-phenol (0.10 mg/kg, 2-fold concentration), 3-keto-7-phenol (0.03 mg/kg, 3-fold concentration), 3-hydroxy-7-phenol (0.04 mg/kg, 2-fold concentration). Processing factors could not be determined for the carbamates.

Sunflowers. In two processing studies in the USA (Tilka, 1981,1982) plots in North Dakota (Interstate 4 Variety, oil seed type) and Minnesota (Royal Hybrid Variety, confectionary type) were treated at planting with Furadan 10 G at 2.2 kg ai/ha and the plants were treated four times with foliar aerial applications of Furadan 4F at 0.56 kg ai/ha. A total application of 4.5 kg ai/ha. The North Dakota crop was harvested 26 days after the last application and the Minnesota crop after 50 days. The seeds were processed by simulated commercial procedures. Confectionary seeds were cracked and separated into hulls and kernels. Oil seed kernels were extracted to obtain crude oil and extracted meal. The crude oil was refined, bleached and deodorized to yield edible oil and soapstock. The seed and processed fractions were analysed for carbofuran and 3-hydroxy-carbofuran by the method of Schreier with the clean-up procedures of Leppert. Control samples were fortified at 0.05 mg/kg (0.1 mg/kg for confectionary seed) and analysed by the trial method. The limit of detection was estimated as 0.01 mg/kg for carbofuran and 3-hydroxy-carbofuran in all samples except soapstock, where it was 0.02 mg/kg. The results are shown in Table 60. The residue levels increased slightly in hulls and meal only.

Table 60. Carbofuran and 3-hydroxy-carbofuran in processed fractions of sunflower seed, and recoveries from fortified control samples.

Fraction	Residue, mg/kg, and [processing factor]		Recovery, %	
	Carbofuran	3-OH -CF	Carbofuran	3-OH -CF

	Residue, mg/kg, and [processing factor]		Recovery, %	
Oil seed	0.10	0.05	76 (0.05 mg/kg)	68 (0.05 mg/kg)
Edible oil	<0.05 (0.01) [0.1]	<0.05 [1]	88 (0.05 mg/kg)	100 (0.05 mg/kg)
Hulls	0.12 [1.2]	0.05 [1]	80 (0.05 mg/kg)	72 (0.05 mg/kg)
Soapstock	<0.05 [0.2]	<0.05 [1]	58 (0.05 mg/kg)	100 (0.05 mg/kg)
Extracted meal	0.10 [1]	0.09 [1.8]	68 (0.05 mg/kg)	76 (0.05 mg/kg)
Confectionary seed	<0.1 [0.06]	<0.1 [0.02]	93 (0.10 mg/kg)	67 (0.10 mg/kg)
Hulls	0.07 [1.2]	<0.05	-	-

Abbreviated compound names: see Figure 1

Cotton. In a processing study in the USA. (Shevchuk, 1994b) Texas cotton was treated with Furadan 4F in two broadcast foliar applications, each at 1.4 kg ai/ha (19 g/l), a total of 5 times the GAP rate. The cotton was harvested at the bloom and bolls growth stage, 27 days after the second treatment. Ginned and delinted cotton seed, hulls, meal and crude oil were analysed for carbofuran and its carbamate and phenol metabolites by the method of Barros. Soapstock was analysed for the phenol metabolites only. The method was validated at 0.03 mg/kg for each analyte in each sample. The recoveries from duplicate controls fortified at 0.03 mg/kg and the results of the trial are shown in Table 61. Sample chromatograms were included for the phenol but not for the carbamate determinations. There was no concentration of residues except in soapstock, where the 7-phenol was concentrated by a factor of about 7 from an estimated 0.01 mg/kg.

In the processing operation 48.2 kg cotton yielded 15.8 kg kernels and 6.45 kg hulls and the kernels yielded 3.7 kg crude oil and 11.4 kg meal.

Table 61. Carbofuran and metabolites in processed fractions of cotton seed after the foliar application of Furadan 4F (2 x 1.4 kg ai/ha, 27-day PHI), and recoveries from fortified control samples.

Sample	Residue, mg/kg [Processing factor] Recovery, %					
	carbofuran	3-K-CF	3-OH -CF	7-Phenol	3-K 7-P	3-OH-7-P
Ginned cotton seed	0.06 73, 75	<0.03 81, 102	0.19 56, 68	<0.03 (0.01) 106, 106	<0.03 94, 97	<0.03 64, 66
Delinted cotton seed	0.03 [0.5] 84, 88	<0.03 111, 112	<0.03 (0.01) [0.05] 63, 72	<0.03 90, 95	<0.03 103, 113	<0.03 73, 81
Hulls	<0.03 (0.02) [0.4] 72, 82	<0.03 69, 75	<0.03 (0.01) [0.05] 70, 71	<0.03 77, 93	<0.03 96, 101	<0.03 61, 71

Meal	<0.03 (0.02) [0.4] 90, 99	<0.03 85, 86	<0.03 (0.01) [0.05] 68, 71	<0.03 84, 91	<0.03 122, 129	<0.03 122, 128
Crude oil	<0.03 (0.02) [0.4] 90, 101	<0.03 103, 112	<0.03 [0.05] 70, 75	<0.03 (0.01) 60, 61	<0.03 74, 79	<0.03 84, 85
Soapstock	-	-	-	0.07 [7] 57, 64	<0.03 84, 94	<0.03 78, 92

Abbreviated compound names: see Figure 1

Sugar cane. A processing study was carried out in El Salvador (Stearns, 1986c). In the 1985-1986 growing season, ratoon sugar cane was treated twice with Furadan 10G at 2.5 kg ai/ha, as a banded treatment after the 1985 harvest and as a broadcast application about 6 months later, the total application of 5 kg ai/ha being 1.8 times the GAP rate. Mature sugar cane harvested 169 days after the second treatment was processed into brown sugar and molasses, but the process was not described and the molasses were not defined as either blackstrap or edible molasses. Brown sugar was also not defined, but was presumably unrefined sugar, not the commercially available brown sugar. The samples were analysed by the method of Schreier, with an MSD for the phenols and an NPD for the carbamates. Limits of determination were established for the processed fractions but not for the raw cane. Acceptable recoveries were reported at 0.05 mg/kg fortification for the carbamates from brown sugar and molasses and the phenols from molasses and at 0.10 mg/kg for the phenols from brown sugar. Limited chromatographic information was provided. The analyses showed no residues of carbofuran, 3-keto-carbofuran or 3-hydrdoxy-carbofuran in the cane, molasses or brown sugar. The 7-phenol was reported as 0.05 mg/kg in cane, 0.06 mg/kg in molasses (1.2-fold concentration) and 0.12 mg/kg in brown sugar (2.4-fold concentration). The residues of the 3-keto-7-phenol were 0.03 mg/kg in cane, 0.06 mg/kg in molasses (2-fold concentration) and 0.08 mg/kg in brown sugar (2.7-fold concentration), and of the 3-hydroxy-7-phenol 0.05 mg/kg in cane, 0.08 mg/kg (1.6-fold concentration) in both molasses and brown sugar. A limit of detection of 0.02 mg/kg was claimed for all analytes. Processing factors for the carbamate residues could not be estimated as neither the raw nor the processed commodities contained carbamates.

Coffee. In a processing study reported from Minas Gerais, Brazil (Brooks, 1996b) Furadan 5G was applied twice at 3.0 g ai/bush to the soil round coffee plants (Catuai, 1400 cova/ha), the total of 6.0 g ai/bush being twice the GAP rate. The first application (in 1994) was 30 days after flowering and the second (1995) about 6 months later. The PHI was 30 days. The green coffee beans were processed into instant coffee and ground roasted coffee in a laboratory scale operation designed to reflect commercial processing. Green beans (13.8 kg) were roasted (177-221°C hot air for 6 minutes) and a proportion was ground. The remaining beans were brewed and the extract freeze-dried. The spent grounds were press-brewed and the brew added to the extract. The green beans, ground coffee and instant coffee were analysed by the method of Barros. Limits of determination of 0.05 mg/kg for carbofuran and its metabolites on coffee beans only were demonstrated by the analysis of fortified control beans in triplicate. The ranges of recovery were reported as carbofuran 72-94%; 3-keto-carbofuran 64-97%, 3-hydroxy-carbofuran 92-96%, 7-phenol 92-128%, 3-keto-7-phenol 106-138%, and 3-hydroxy-7-phenol 52-82%. The limit of detection was claimed to be 0.01 mg/kg for each analyte. Green bean coffee had a measurable residue of 3-hydroxy-carbofuran, 0.22 mg/kg. Neither instant coffee nor roasted beans contained carbamates (<0.01 mg/kg, processing factor 0.05). Both the green beans and the processed commodities contained all the three phenol metabolites with higher levels in the processed commodities. The phenolic residues are shown in Table 62.

Table 62. Residues of phenol metabolites in or on green beans, roasted coffee and instant coffee from the application of Furadan 5G to the soil around coffee bushes in brazil, 2 x 3 g ai/bush, 30-day PHI.

Commodity	7-phenol		3-keto-7-phenol		3-hydroxy-7-phenol	
	Residue, mg/kg	Processing factor	Residue, mg/kg	Processing factor	Residue, mg/kg	Processing factor
Green beans	0.14	-	0.07	-	0.28	-
Ground roast	0.17	1.2	0.08	1.1	0.45	1.6
Instant	0.47	3.4	0.21	3.0	0.43	1.5

<u>Pimento peppers</u>. In a processing study in the USA (Anon., 1971). Furadan 10 G was applied to pimento pepper plots in Delaware in two side-dress treatments at 2.2 and 3.4 kg ai/ha . Pimentos were harvested at maturity and pickled by an undefined method. Residues of carbofuran and 3-hydroxy-carbofuran were determined by the method of Schreier, using a gas chromatograph equipped with a Coulson nitrogen detection system. The limits of determination were established by the analysis of fortified peppers and pickled peppers. At 0.05 mg/kg the recoveries from peppers were 114 and 132% for carbofuran and 94 and 70% for 3-hydroxy-carbofuran. At 0.20 mg/kg the recoveries from fortified pickled peppers (6 replicates) were 89 ± 9.5% for carbofuran and 62 ± 10% for 3-hydroxy-carbofuran. Finite residues were found on the raw peppers which were reduced by pickling. The results are shown in Table 63.

Table 63. Residues of carbofuran and 3-hydroxy-carbofuran in or on pimento peppers and pickled peppers from the application of Furadan 10 G as a banded treatment (2.2 + 3.4 kg ai/ha) in 1971 in Delaware, USA.

PHI, days	Residue, mg/kg			
	Raw peppers		Pickled peppers	
	carbofuran	3-hydroxy-carbofuran	carbofuran	3-hydroxy-carbofuran
21	0.35	0.13	0.19	0.08
	0.35	0.23	0.19	0.08
39	0.10	0.15	<0.2	<0.2

<u>Grapes</u>. Furadan 4F was applied as a broadcast treatment at the GAP rate of 11 kg ai/ha (29 g/l) to grape plants (Pinot Blanc) in California in 1985 (Stearns, 1986b). Grapes were harvested at maturity after a PHI of 198 days and processed into juice and wet and dry pomace. No information was supplied on the processing. The samples were analysed by the method of Schreier, carbamates being determined with an NPD and phenols with an MSD. Limits of determination were demonstrated by the analysis of duplicate control samples of grapes fortified at 0.10 mg/kg and juice and dry pomace at 0.05 mg/kg with carbofuran and each of the carbamate and phenol metabolites. Levels of detection

of 0.01 and 0.02 mg/kg were claimed for the carbamates and phenols respectively. The results are shown in Table 64. Residues were not concentrated in the juice but were concentrated in dry pomace (3-hydroxy-carbofuran 2.8-fold and total phenols 3.9-fold).

Table 64. Residues of carbofuran and its metabolites in grapes, juice and pomace from the application of Furadan 4F, 11 kg ai/ha, 198-day PHI and recoveries from fortified control samples.

Commodity	Residues, mg/kg Recoveries, %[1]					
	Carbofuran	3-K-CF	3-OH-CF	7-Phenol	3-K-7-P	3-OH-7-P
Grapes	<0.1 83 (76, 90)	<0.1 98 (78, 117)	0.20 98 (79, 117)	<0.1 (0.07) 87	0.1 93	0.14 0
Juice	<0.05 84 (84, 84)	<0.05 90 (86, 94)	0.18 98 (102, 94)	<0.05 (0.04) 89 (96, 82)	0.07 96 (104, 87)	0.12 89 (97, 81)
Dry Pomace	<0.05 (0.01) 67 (62, 72)	<0.05 (0.02) 68 (66, 70)	0.56 67 (62, 72)	0.32 84 (82, 85)	0.44 104 (103, 105)	0.44 75 (74, 76)

[1]Grapes fortified at 0.1 mg/kg, juice and pomace at 0.05 mg/kg with each analyte

Residues in the edible portion of food commodities

No data were submitted.

RESIDUES IN FOOD IN COMMERCE OR AT CONSUMPTION

A farm gate study was submitted from Korea (Chon Chae-gu, 1996) in which seven domestic commodities were analysed for carbofuran in the period April 1995-January 1996. A total of 210 samples of rice, carrots, maize, green onions, potatoes, peanuts and garlic were collected from farms (only brown rice) or markets (all commodities except rice) near the sites of production in various growing regions of the country. Residues were analysed by the method of Leppert, but the ethoxylation step was omitted. A 10 m RSL-300TM or a 25 m methyl silicone capillary column was used with a nitrogen-phosphorus detector. Calibration was by external standards and only carbofuran was determined, although several sample chromatograms showed a peak labelled 3-hydroxy-carbofuran. Results are shown in Table 65.

Table 65. Monitoring of carbofuran residues in seven domestic commodities in Korea, 1995-1996.

Commodity	No. of samples	No. of detections[1]	Detection frequency, %	Carbofuran, mg/kg	Recoveries	
					Fortification, mg/kg	%
Brown rice	60	1	1.7	<0.5 (0.06)	0.5	106, 107, 108
Garlic	40	2	5.0	<0.1 (0.07, 0.13)	0.1	95.5, 91.3, 95.8, 96,1, 97.6, 94.9
Peanuts	20	0	0	<0.1	0.1	98.4, 92.4, 96.2
Potato	10	0	0	<0.1	0.1	100.1, 92.6, 97.3
Green onions	40	0	0	<0.25	0.25	81.9, 83.5, 83.4
Carrots	20	2	10	<0.25 (0.015, 0.015)	0.25	92.0, 92.8, 91.2
Corn (maize)	20	0	0	<0.25	0.25	95.0, 94.5, 94.0

[1] Limit of detection estimated at 0.05 mg/kg for rice, 0.0125 mg/kg for carrots, maize and green onions and 0.02 mg/kg for garlic, peanuts and potatoes. These limits were based on injections of standards and do not reflect the effect of the matrix

NATIONAL MAXIMUM RESIDUE LIMITS

Maximum residue limits, which have been established in 31 countries and the EU are shown below.

Country	Commodity	MRL, mg/kg	Remark
Argentina	Bean	0.1	
	Eggs	0.05	
	Fat	0.05	
	Maize grain	0.1	
	Meat	0.05	
	Meat by-products	0.05	
	Milk	0.05	
	Potato	0.5	
	Sorghum grain	0.1	
	Sweet corn	0.1	
	Tomato	0.1	
Australia			Sum of carbofuran and 3-hydroxy-carbofuran, expressed as carbofuran
	Animal feed	2	
	Banana	0.1	
	Eggs	0.05*	
	Meat	0.05*	
	Meat by-products	0.05*	
	Milk	0.05*	
	Poultry meat	0.05*	
	Rice	0.2	
	Sugar cane	0.1*	
	Wheat	0.2	
Austria			Carbofuran, 3-hydroxy-carbofuran and its conjugates, expressed as carbofuran
	Beet, Sugar	0.2	

Country	Commodity	MRL, mg/kg	Remark
	Coffee		
	Grape	0.2	
	Maize	0.2	
	Meat	0.05	
	Milk	0.05	
	Sunflower seed	0.1	
	Potato	0.5	
	Turnips	1	
Belgium			Carbofuran and 3-hydroxy-carbofuran, expressed as carbofuran
	Plant commodities	0	<0.1 mg/kg
Brazil	Coffee	0.1	
	Cotton seed	0.1	
	Peanut	0.1	
	Rice	0.2	
Canada			Sum of carbofuran and 3-hydroxy-carbofuran, expressed as carbofuran
	Alfalfa	0.1	Negligible tolerance
	Banana	0.1	Negligible tolerance
	Barley	0.1	Negligible tolerance
	Beet, Sugar	0.1	Negligible tolerance
	Clover	0.1	Negligible tolerance
	Coffee	0.1	Negligible tolerance
	Cucumber	0.1	Negligible tolerance
	Eggs	0.1	Negligible tolerance
	Grape	0.1	Negligible tolerance
	Maize	0.1	Negligible tolerance
	Meat	0.1	Negligible tolerance
	Melon	0.1	Negligible tolerance
	Milk	0.1	Negligible tolerance
	Oats	0.1	Negligible tolerance
	Peanut	0.1	Negligible tolerance
	Pepper, Sweet	0.5	
	Potato	0.5	
	Pumpkin	0.1	Negligible tolerance
	Rape seed	0.1	Negligible tolerance
	Rice	0.1	Negligible tolerance
	Rutabaga	0.5	
	Strawberry	0.4	
	Sunflower	0.1	Negligible tolerance
	Tomato	0.1	Negligible tolerance
	Wheat	0.1	Negligible tolerance
Chile			Sum of carbofuran and 3-hydroxy-carbofuran, expressed as carbofuran
	Animal fat	0.05*	
	Barley	0.1*	
	Beat, sugar	0.1*	
	Mammalian, meat	0.05*	
	Milk	0.05*	
	Oilseed	0.1*	
	Potato	0.5	
	Rice, husked	0.2	
	Tomato	0.1*	
	Wheat	0.1*	
Cyprus	Banana	0.1	
	Beets, sugar	0.1	
	Cereals	0.1	

Country	Commodity	MRL, mg/kg	Remark
	Meat	0.05	
	Milk	0.05	
	Potato	0.05	
	Rice	0.02	
	Strawberry	0.1	
	Tomato	0.1	
Denmark			Sum of carbofuran and 3-hydroxy-carbofuran, expressed as carbofuran
	Banana	0.1	
	Potato	0.5	
	Turnips, swedes	0.1	
European Union			Sum of carbofuran and 3-hydroxy-carbofuran, expressed as carbofuran
	Banana	0.1*	T
	Cereals	0.1*	
	Cotton seed	0.1*	T
	Cucurbits	0.1*	
	Egg products	0.1*	
	Eggs	0.1*	T
	Grape	0.1*	T
	Meat	0.1*	T
	Meat by-products	0.1*	
	Meat, preparations of	0.1*	
	Melon	0.1*	T
	Milk	0.1*	
	Milk products	0.1*	
	Oats	0.1*	T
	Peanut	0.1*	T
	Potato	0.1*	T
	Rape seed	0.1*	T
	Rice	0.1*	T
	Rubus species (cane fruit)	0.1*	
	Rutabaga	0.01	T
	Soya	0.1*	T
	Strawberry	0.1*	T
	Sunflower seed	0.1*	T
	Sweet corn	0.1*	T
	Turnip, edible	0.01	T
Finland			Sum of carbofuran and 3-hydroxy-carbo expressed as carbofuran
	Potato	0.5	
France			Sum of carbofuran and 3-hydroxy-carbo expressed as carbofuran
	Maize forage	0.5	T
	Maize grain	0.1	
	Rape	0.5	
	Soya	0.2	
	Strawberry	0.5	
	Sunflower	0.5	
	Sweet corn	0.5	
	Sweet corn, forage	0.5	T
Germany			Carbofuran, 3-hydroxy-carbofuran and its conjugates, expressed as carbofuran
	Animal fat	0.05	
	Beet, Sugar	0.2	
	Egg products	0.05	
	Eggs	0.05	

Country	Commodity	MRL, mg/kg	Remark
	Meat	0.05	
	Meat, preparations of	0.05	
	Milk	0.05	
	Milk products	0.05	
	Other plant commodities	0.1	
	Potato	0.5	
Hungary	Other plant commodities	0.1	
India			Sum of carbofuran and 3-hydroxy-carbofuran, expressed as carbofuran
	Cereal grains	0.1	
	Fruit	0.1	
	Oilseed	0.1	
	Sugar cane	0.1	
	Vegetables	0.1	
	Meat	0.1	Fat basis
	Milk	0.05	Fat basis
	Milk products	0.05	Fat basis
	Poultry	0.1	
Italy	Beet, Sugar	0.1	
	Maize	0.1	
	Potato	0.1	
Kenya	Alfalfa		T
	Alfalfa hay	20	T
	Banana	0.1	T
	Barley	0.1	T
	Beet, Sugar, leaf	0.2	T
	Beet, Sugar, root	0.1	T
	Cattle fat	0.05*	T
	Cattle meat	0.05*	T
	Cattle meat by-products	0.05*	T
	Coffee	0.1	T
	Goat fat	0.05*	T
	Goat meat	0.05*	T
	Goat meat by-products	0.05*	T
	Horse fat	0.05*	T
	Horse meat	0.05*	T
	Horse meat by-products	0.05*	T
	Maize	0.1	T
	Maize, forage		T
	Milk	0.05*	T
	Oats	0.1	T
	Oilseed	0.1	T
	Peanut kernel	0.1	T
	Pig fat	0.05*	T
	Pig meat	0.05*	T
	Pig meat by-products	0.05*	T
	Potato	0.5	T
	Rice, husked	0.2	T
	Sheep fat	0.05*	T
	Sheep meat	0.05*	T
	Sheep meat by-products	0.05*	T
	Sorghum	0.1	T
	Soya	0.2	T
	Strawberry	0.1	T
	Sugar cane	0.1	T
	Sweet corn kernels	0.1	T
	Tomato	0.1	T

Country	Commodity	MRL, mg/kg	Remark
	Wheat	0.1	T
Luxembourg	Maize	0.1	Sum of carbofuran and 3-hydroxy-carbofuran, expressed as carbofuran
Malaysia	Banana	0.1	
	Grape	0.4	
	Strawberry	0.5	
Mexico	Alfalfa	10	
	Alfalfa hay	40	
	Banana	0.1	
	Barley	0.2	
	Coffee	0.1	
	Cucumber	0.4	
	Grape	0.4	
	Maize	0.1	
	Melon	0.4	
	Oats	0.2	
	Peanut	4	
	Pepper, Cayenne	1	
	Pepper, Sweet	1	
	Potato	2	
	Rice	0.2	
	Sorghum	0.1	
	Soya	1	
	Strawberry	0.5	
	Sugar cane	0.1	
	Wheat	0.2	
Netherlands			Sum of carbofuran and 3-hydroxy-carbofuran, expressed as carbofuran
	Potato	0.5	
	Rice	0.2	
	Soya	0.2	
	Strawberry	0.2	
	Other plant commodities	0.1*	
Paraguay	Rice	0.2	
	Tomato	0.1	
Portugal	Potato	0.5	Sum of carbofuran and 3-hydroxy-carbofuran, expressed as carbofuran
South Africa			Sum of carbofuran and 3-hydroxy-carbofuran, expressed as carbofuran
	Cruciferae	0.5	
	Maize	0.1	
	Maize forage	0.2	
	Potato	0.05	
	Sorghum	0.1	
	Sugar cane	0.1	
	Sunflower seed	0.1	
	Wheat	0.1	
South Korea	Banana	0.1	
	Barley	0.1	
	Coffee	0.1	
	Cotton seed	0.1	
	Cucumber	0.5	
	Grape	0.5	
	Maize	0.1	
	Oats	0.1	
	Peanut	0.5	
	Potato	0.5	

Country	Commodity	MRL, mg/kg	Remark
	Pumpkin	0.5	
	Rice	0.2	
	Sorghum grain	0.1	
	Soya	0.2	
	Strawberry	0.1	
	Sunflower seed	0.1	
	Tomato	0.1	
	Wheat	0.1	
Spain			Sum of carbofuran, carbosulfan and 3-hydroxy-carbofuran, expressed as carbofuran
	Sweet corn	0.1*	
	Cotton seed	0.1*	
	Cucurbits with edible peel	0.1*	
	Cucurbits with inedible peel	0.1*	
	Forage crops and straw	0.1*	
	Grape	0.1*	
	Maize forage	2	
	Oats	0.1*	
	Oil seed	0.1*	
	Other pulses	0.1*	
	Peanut	0.1*	
	Potato	0.2	
	Rape seed	0.1*	
	Rice	0.1*	
	Rubus species (cane fruit)	0.1*	
	Rutabaga	0.1*	
	Solanaceae (peppers)	0.1*	
	Sorghum forage	2	
	Soya	0.1*	
	Stimulant plants (coffee)	0.1*	
	Strawberry	0.1*	
	Sugar plants	0.1*	
	Sunflower seed	0.1*	
	Turnip, edible	0.1*	
Sri Lanka	Banana	0.2	
	Gourd	1	
Sweden			Sum of carbofuran and 3-hydroxy-carbofuran, expressed as carbofuran
	Fruit	0.1	
	Potato	0.5	
	Other vegetables	0.1	
Switzerland	Beet, Sugar	0.05*	
	Maize	0.05*	
UK			Sum of carbofuran and 3-hydroxy-carbofuran, expressed as carbofuran
	Banana	0.1*	
	Barley	0.1*	
	Beet, Sugar	0.1*	
	Cereals exc. rice	0.1*	
	Cucumber	0.1*	
	Cucurbits	0.1*	
	Eggs	0.1*	
	Fat	0.1*	
	Grape	0.1*	
	Maize	0.1*	
	Meat	0.1*	
	Meat, preparations of	0.1*	

Country	Commodity	MRL, mg/kg	Remark
	Milk	0.1*	
	Milk products	0.1*	
	Oil seed	0.1*	
	Pepper, Sweet	0.1*	
	Rye	0.1*	
	Squash	0.1*	
	Tomato	0.1*	
	Wheat	0.1*	
	Wine grape	0.1*	
Uruguay	Potato	0.5	
	Rice	0.2	
	Tomato	0.1	
USA			Carbofuran, 3-hydroxy-carbofuran
	Alfalfa		
	Alfalfa hay	20	
	Banana	0.1	
	Barley grain	0.1	
	Barley straw	1	
	Beet, Sugar	0.1	
	Beet, Sugar, top or leaves	1	
	Cattle fat	0.02	
	Cattle meat	0.02	
	Cattle meat by-products	0.02	
	Coffee	0.1	
	Cotton seed	0.2	
	Cucumber	0.2	
	Goat fat	0.02	
	Goat meat	0.02	
	Goat meat by-products	0.02	
	Gourd	0.6	
	Grape	0.2	
	Grape pomace, dried	1.5	F
	Grape, raisin	1	F
	Grape, raisin waste	3	F
	Horse fat	0.02	
	Horse meat	0.02	
	Horse meat by-products	0.02	
	Maize fodder		
	Maize forage		
	Maize grain	0.1	
	Maize, fresh	0.2	
	Melon	0.2	
	Milk	0.02	
	Oat grain	0.1	
	Oat straw	1	
	Peanut	1.5	
	Peanut hull	8	
	Peanut soapstock	3	F
	Pepper, Cayenne	0.2	
	Pepper, Sweet	0.2	
	Pig fat	0.02	
	Pig meat	0.02	
	Pig meat by-products	0.02	
	Popcorn grain	0.1	
	Potato	1	
	Pumpkin	0.6	
	Rape, canola seed	0.2 T	Until 22/02/98

Country	Commodity	MRL, mg/kg	Remark
	Rice	0.2	
	Rice straw	0.2	
	Sheep fat	0.02	
	Sheep meat	0.02	
	Sheep meat by-products	0.02	
	Sorghum fodder	0.5	
	Sorghum forage	0.5	
	Sorghum grain	0.1	
	Soya	0.2	
	Soya forage	20	
	Soya hay	20	
	Soya soapstock	1	F
	Strawberry	0.2	
	Sugar cane	0.1	
	Sunflower meal	0.6	F
	Sunflower seed	0.5	
	Sunflower soapstock	0.5	F
	Sunflower, hull	0.6	F
	Sweet corn, fresh	0.2	
	Wheat grain	0.1	
	Wheat straw	1	

*At or about the limit of determination
F: Food-additive tolerance
T: Temporary

APPRAISAL

Carbofuran, 2,3-dihydro-2,2-dimethylbenzofuran-7-yl methylcarbamate, is a widely used insecticide, nematicide, and acaracide. Its uses include seed treatment, at-plant soil application, and directed or foliar applications. A periodic review of the toxicology of carbofuran was carried out by the 1996 JMPR and the present evaluation is a periodic review of its residue and analytical aspects.

Carbosulfan produces carbofuran as a major metabolite. The periodic review of carbosulfan at the present Meeting includes an evaluation of its use on citrus fruit. In evaluating carbofuran, account was taken of its residues arising from the use of carbosulfan on citrus.

Animal metabolism

Studies were provided by the sponsors on rats, houseflies, laying hens, and lactating goats. The metabolism is similar in all species and consists of oxidation at the C-3 position and hydrolysis of the carbamate ester. The major metabolites observed in the urine from rats treated orally with single doses of carbonyl- or phenyl-labelled [^{14}C]carbofuran were 3-hydroxycarbofuran (14%), 3-ketocarbofuran (48%), the 7-phenol (20%), and the 3-hydroxy-7-phenol (1.4%). The major compounds found from the topical treatment of houseflies with radiolabelled carbofuran were carbofuran (12% internal), 3-hydroxycarbofuran (6%), and conjugated 3-hydroxycarbofuran (11%).

Hens were given 3 mg of phenyl-labelled [^{14}C]carbofuran for 7 consecutive days, about 2 mg/kg bw/day, equivalent to about 25 ppm in the feed. Eggs and tissues were collected and subjected to a series of extractions and hydrolyses. The residues in muscle and fat were negligible, and radiolabelled residues in the kidneys, liver, and eggs ranged from 0.03 to 0.15 mg/kg expressed as carbofuran. The major metabolite found in eggs was the 3-hydroxy-7-phenol (39% of the TRR).

About 5% of the TRR in the liver and kidneys was identified as the 7-phenol, and significant proportions were characterized as releasable by treatment with protease or strong acid.

[^{14}C]Carbofuran, uniformly labelled in the phenyl ring, was administered orally to goats for 7 consecutive days at a rate equivalent to 25 ppm carbofuran in the diet. Milk and excreta were collected daily, and tissues were taken within 24 hours of the final dosing. The total radioactive residue in the milk remained fairly constant (0.10 mg/kg), and residues in the fat and tissues were negligible (<0.01 mg/kg). The milk and tissues were extracted with a series of solvents and subjected to enzymatic and acid/base hydrolyses. The major metabolites released and subsequently identified in the milk were 3-hydroxycarbofuran (10% of the TRR), the 7-phenol (15% of the TRR), and the 3-keto-7-phenol (32% of the TRR). Protease released 13% and 16% of the TRR from the kidneys and liver respectively. Major metabolites in the kidneys were 3-hydroxycarbofuran (11% of the TRR) and the 3-hydroxy-7-phenol (16% of the TRR, enzyme-released).

Plant metabolism

Studies were reported on potatoes, soya beans, and maize. The major metabolites identified in potato tubers were the 7-phenol (45% of the TRR) and the 3-hydroxy-7-phenol (13%). Immature foliage contained 3-hydroxycarbofuran (23% of the TRR) and a metabolite unique to the potato, 5-hydroxycarbofuran (34%). In soya bean forage (45-day PHI), the major compounds were identified as carbofuran (11% of the TRR) and 3-hydroxycarbofuran (28%). At a longer pre-harvest interval (139 days), the beans showed a substantial residue (40% of the TRR) releasable only by enzymes and acid and base hydrolyses. Only 12-13% the residue in the beans and hay was identified. The major metabolites in the beans were 3-ketocarbofuran (5% of the TRR) and the 3-keto-7-phenol (9%). The main compounds identified in maize forage were carbofuran and 3-hydroxycarbofuran (14% and 13% of the TRR).

The metabolites identified or characterized in the plants are consistent with hydroxylation at C-3 and hydrolysis of the carbamate, as in animals. Substantial conjugation of the metabolites and incorporation of the radiolabel into plant constituents occur.

The Meeting concluded that the animal and plant metabolism studies were fully adequate and showed a common metabolic pathway.

Environmental fate

Studies were reported on aerobic soil degradation, aerobic and anaerobic aquatic degradation, soil photolysis, terrestrial field dissipation, aqueous photolysis, and aquatic field dissipation.

The major pathway of degradation of [^{14}C]carbofuran in aerobic soil was by hydroxylation and oxidation at the C-3 position, yielding 3-hydroxycarbofuran and 3-ketocarbofuran. The half-life of carbofuran was calculated to be 320 days under acidic conditions and 150 days under alkaline conditions.

In an anaerobic water/sediment study more than 50% of the [^{14}C]carbofuran was converted to the 7-phenol, which was also a major product of anaerobic aquatic degradation where the carbofuran half-life was 120 days.

The aerobic aquatic half-life in a water/sediment system at pH 5.4 was 40 days.

The photolysis half-life of carbofuran in soil was about 78 days. Carbofuran is photolytically stable in aqueous solution, with a half-life of 450-1200 days.

From the soil dissipation studies it was determined that the half-life of carbofuran at a 0-6 inch depth was 13-43 days. The aquatic field dissipation study showed a carbofuran half-life of <10 days for carbofuran in rice paddy water. Thus, transfer of carbofuran via irrigation water is not anticipated to be a serious concern.

It was shown that carbofuran can be leached from four different types of soil under vigorous conditions.

The Meeting concluded that carbofuran is readily degraded in aquatic systems and that it is somewhat persistent is soil. Degradation in soil and water involves hydroxylation at the C-3 carbon and hydrolysis of the carbamate.

Methods of residue analysis

The methods of analysis are adequate for monitoring and for use in supervised trials, and at least one multi-residue method exists which is suitable for monitoring and enforcement.

The commonly used HPLC method involves solvent extraction of the homogenized sample, purification on a solid-phase extraction column, and determination on a reverse-phase column. A post-column reactor converts the eluted methylcarbamates to an indole, which is measured fluorimetrically. The method has a demonstrated limit of determination of about 0.05 mg/kg for carbofuran, 3-hydroxycarbofuran, and 3-ketocarbofuran. The limit of determination in milk is 0.025 mg/kg. A variation of the method involves initial hydrolysis of the homogenized sample with 0.25 N HCl to release any conjugates.

Several GLC methods exist for the determination of the carbamate metabolites. A macerated sample is refluxed with 0.25 N HCl, partitioned into methylene chloride, and purified on a Florisil column. A methyl silicone capillary column and a nitrogen-phosphorus or mass spectrometric detector are used. The method may be modified by ethylating the 3-hydroxycarbofuran. Limits of determination of 0.05 to 0.10 mg/kg were demonstrated.

In an older variation of the GLC method the initial extraction of the sample is with methanol/chloroform. The residual aqueous fraction is then hydrolysed with acid. A limit of determination of 0.1 mg/kg is claimed, but recoveries of the conjugate of 3-hydroxycarbofuran were generally unacceptable below 1 mg/kg. A variation of this method did not include acid hydrolysis, and the limit of determination for carbofuran and 3-hydroxycarbofuran was 0.1 mg/kg.

Stability of residues in stored analytical samples

Information was submitted on the stability of carbofuran, 3-hydroxycarbofuran, and 3-ketocarbofuran in or on several diverse raw agricultural commodities. The Meeting concluded that carbofuran and its carbamate metabolites are stable for at least 2 years in or on frozen plant commodities and milk, and for 1 year in meat.

Definition of the residue

The residue is defined for compliance with MRLs as the sum of carbofuran and 3-hydroxycarbofuran, expressed as carbofuran. For the estimation of dietary intake the residue should be defined as the sum of carbofuran, free 3-hydroxycarbofuran and conjugated 3-

hydroxycarbofuran, expressed as carbofuran. The metabolism studies on soya beans and maize showed that the concentration of conjugated 3-hydroxycarbofuran was equal to or greater than that of 3-hydroxycarbofuran. For example, in soya bean forage (63 mg/kg of ^{14}C expressed as carbofuran) the free 3-hydroxycarbofuran was 11% of the TRR and the conjugated (acid-released) 3-hydroxycarbofuran was 17%. In the beans the concentrations were approximately equal. Where the analytical method used for a field trial did not include an acid hydrolysis step (refluxing with 0.1 N HCl) to release conjugates of 3-hydroxycarbofuran, the results were not used in the determination of the STMR levels.

Supervised trials

Residue trials were reported on numerous crops: alfalfa, bananas, Brussels sprouts, cantaloupes, cauliflower, celeriac, celery, coffee, cucumbers, grapes, head cabbages, kohlrabi, leeks, maize, oilseed plants (cotton, sunflower, rape, peanuts), onions, peppers, potatoes, rice, sorghum, soya beans, strawberries, sugar beet, sugar cane, summer squash, sweet corn, tomatoes, turnips, and wheat.

Fruits

Citrus fruits. Residues of carbofuran, 3-hydroxycarbofuran, and 3-ketocarbofuran may occur on citrus from the use of carbosulfan. On the basis of the concurrent review of carbosulfan the Meeting estimated a maximum residue level for carbofuran plus 3-hydroxycarbofuran in oranges of 0.5 mg/kg, and an STMR of 0.1 mg/kg.

Grapes. Field trials in the USA, Germany, and Mexico were reported. The four trials in Germany were not considered because the residue determined and the maturity of the crop samples were not clearly explained; the report consisted only of a simple summary. US GAP was used to evaluate the trials in Mexico and the USA (11.2 kg ai/ha of 4 F formulation, applied after harvest with a PHI of 200 days and soil-incorporated; pre-harvest drip irrigation with 4F at 3.4 kg ai/ha, 60-day PHI). One US and three Mexican trials complied with GAP for the vine treatment after harvest, and one US trial with GAP for the pre-harvest treatment. The residues were <0.05 mg/kg in all five trials, but five trials were considered to be insufficient for the estimation of a maximum residue level.

Strawberries. Supervised field trials were reported from France (0.89-1 kg ai/ha, PHI 13-48 days), the UK (2 kg ai/ha, 300-day PHI), and the USA (2.2 kg ai/ha, 250-day PHI). The results constituted two distinct sets, one for the after-harvest application to vines (UK and USA) where residues were below the limit of determination, 0.05-0.1 mg/kg, and the other with residues from <0.1 to 0.94 mg/kg (France). No information on GAP was provided for France or the UK or a neighbouring nation. The US trials conformed to US GAP, 2.2 kg ai/ha applied post-harvest after 1 October. The residues in the three trials were all 0.02 mg/kg. The results were insufficient to estimate a maximum residue level and the Meeting recommended the withdrawal of the existing CXL (0.1* mg/kg).

Bananas. Field trials in Spain, Central America and South America with the application of carbofuran to banana trees were reported. No residues of carbofuran plus 3-hydroxycarbofuran (<0.02-<0.10 mg/kg, n = 8) were found in any trial. GAP was available only for Spain, where the trial was according to GAP and undetectable residues were <0.02 mg/kg. Because none of the trials, some of which were at higher rates than GAP, yielded detectable residues the Meeting estimated a maximum residue level of 0.1* mg/kg, the same as the existing CXL, and an STMR of 0.1 mg/kg.

Vegetables

Leeks. Curaterr 200 SC was applied to the soil before planting leeks at two locations in The Netherlands. Carbamate residues were above the limit of determination in one trial, with a maximum of 0.15 mg/kg. The number of trials was inadequate to estimate a maximum residue level.

Onions. Curaterr 5G or 200 SC was applied to onions at three locations after or before sowing. The carbamate residues were below the limit of determination. There were too few trials to estimate a maximum residue level. The Meeting recommended withdrawal of the existing CXL for bulb onion (0.1* mg/kg).

Head cabbages. Two supervised field trials were reported for the application of Curaterr 200 SC to head cabbage in The Netherlands. No residues were detected (<0.1 mg/kg). Two trials are too few for the estimation of a maximum residue level and the Meeting recommended the withdrawal of the existing CXL (0.5 mg/kg).

Brussels sprouts. Again only two trials in The Netherlands were reported. The Meeting recommended the withdrawal of the existing CXL (2 mg/kg).

Cauliflower. Five trials were carried out in The Netherlands with Curaterr 200 SC applied to cauliflower plants at 0.038 g ai/plant. The mode and timing of the application were not reported. No GAP was available for The Netherlands or other EU country and the data could not be evaluated. The Meeting recommended the withdrawal of the existing CXL (0.2 mg/kg).

Kohlrabi. Two field trials were carried out in Germany with single applications of a granular formulation at 0.64 g/m 38 and 52 days after planting but no GAP was reported. The Meeting recommended the withdrawal of the existing CXL (0.1* mg/kg).

Cucumbers. Field trials were carried out in the USA. US GAP specifies the at-plant application of 2.2 kg ai/ha of a G formulation or 1.7 kg ai/ha of an F formulation. The trials were conducted at 1.1 and 3.4 kg ai/ha with both the 15 G and 4 F formulations. The lower rate is below maximum GAP and the higher exceeds it. The results from the two rates were comparable and could therefore be used to represent the GAP rate. The residues from the 1.1 kg ai/ha rate were 0.02 (6), 0.04, 0.05, 0.08, 0.09, 0.15 (2), 0.16 and 0.21 mg/kg (n = 14), and those from the 3.4 kg ai/ha rate were 0.02 (4), 0.04 (2), 0.05 (2), 0.13, 0.16, 0.18, 0.21, 0.26 and 0.29 mg/kg, n = 14. The STMR for the 3.4 kg ai/ha rate is 0.05 mg/kg, and that for the 1.1 kg ai/ha rate 0.045 mg/kg. The Meeting estimated a maximum residue level of 0.3 mg/kg and an STMR of 0.05 mg/kg from the combined results.

Cantaloupes. Supervised field trials in the USA were reported, with the application of Furadan 15G or 4F to cantaloupes at planting, with PHIs of 60-92 days. The application rates were 1.1 or 3.4 kg ai/ha. Four trials were conducted in each of seven states. GAP specifies at-plant application of the G formulation at 2.2 kg ai/ha or the F formulation at 1.7 kg ai/ha. Some trials were below and others above maximum GAP. The results from the high and low application rates were similar, and could be used to represent residues resulting from GAP applications. The residues from the 1.1 kg ai/ha rate were 0.02 (8), 0.05 (2), 0.11 (3) and 0.13 mg/kg (n = 14), and those from the higher rate 0.02 (7), 0.05 (5), 0.11 and 0.12 mg/kg (n = 14). The STMR for the 1.1 kg ai/ha rate would be 0.02 mg/kg, and for the 3.4 kg ai/ha rate 0.035 kg ai/ha. Combining the distributions, the STMR is 0.02 mg/kg. The Meeting estimated a maximum residue level of 0.2 mg/kg.

Summer squash. GAP in the USA is the same as for cucumbers and cantaloupes. Supervised field trials were carried out in seven states of the USA with the at-plant application of carbofuran 15G and 4F formulations at 1.1 and 3.4 kg ai/ha, some therefore below and some above maximum GAP. The results from the high and low application rates were similar, and the trials may be taken to represent applications according to GAP. The residues in rank order from 1.1 kg ai/ha were 0.02 (7), 0.05 (2), 0.07, 0.10, 0.11, 0.13 and 0.26 mg/kg (n = 14), and from 3.4 kg ai/ha 0.02 (5), 0.04, 0.06 (3), 0.07, 0.08, 0.09, 0.12 and 0.15 mg/kg (n = 14). The STMR for the 1.1 kg ai/ha rate is 0.035 mg/kg, and for both 3.4 kg ai/ha and for all the trials combined 0.05 mg/kg. The Meeting estimated a maximum residue level of 0.3 mg/kg and an STMR of 0.05 mg/kg.

Peppers (hot). Carbofuran was applied to the soil before planting hot peppers in two trials in the USA, with a second post-emergence side-dress application. The trials were according to, but not at the maximum, US GAP. No maximum residue level could be estimated.

Peppers (sweet). Furadan 4F was applied to sweet peppers in Canada and the USA. GAP was not available for Canada. US GAP specifies two applications of a 4 F formulation, one at-plant and the second as a side-dress, with a 21-day PHI. Each application is 3.4 kg ai/ha. The Canadian applications were in excess of US GAP at 5 x 0.56 kg ai/ha, 1-3-day PHI, and the results were not evaluated. In the US trials the application rate was ≤50% of the maximum GAP rate. The Meeting concluded that the data were insufficient to estimate a maximum residue level.

Tomatoes. Field trials were carried out in Brazil, Canada, France, Mexico, and the USA. The government of Thailand provided information on field trial conditions but did not include any analytical results. Most of the treatments were with a granular formulation applied to the soil round the plants. No GAP was reported for France, Mexico, or Canada, and the results from these countries could not be evaluated. There is no GAP in the USA. Two trials in Brazil which complied with GAP gave results of 0.05 mg/kg, but two samples are not enough to estimate a maximum residue level. The Meeting recommended withdrawal of the existing CXL (5 mg/kg).

Sweet corn (corn-on-the-cob). The findings of sixteen field trials on sweet corn were submitted from the USA. A combination of at-planting, at whorl, and foliar applications were made with granular and flowable formulations in accordance with the current label, at the maximum rate and with a minimum PHI. The commodity analysed was corn and cob, less husk. GAP was followed (1.12 kg ai/ha at-plant, followed by 4 foliar applications, each 0.56 kg ai/ha, 7-day PHI), and the total carbamate residues (carbofuran + 3-hydroxycarbofuran) in rank order were <0.03 (6), 0.03 (4), 0.04 (4), 0.05 and 0.08 mg/kg (n = 16). The Meeting estimated a maximum residue level of 0.1 mg/kg and an STMR of 0.03 mg/kg.

Soya beans. Trials were reported from Brazil, France, and the USA. Brazilian GAP specifies at-plant application of a 10% G at 1.5 kg ai/ha. US GAP allows 2.0 kg ai/ha at-plant or 2 applications at 0.56 kg ai/ha/application. No information on GAP was available for France or a neighbouring country. Only two trials according to GAP were reported, one from Brazil and the other from the USA. The residue in Brazil was below the limit of detection (0.05 mg/kg) and that in the USA was at the limit of determination (0.10 mg/kg). Two results are inadequate to estimate a maximum residue level, and the Meeting recommended withdrawal of the existing CXL for soya bean (dry) of 0.2 mg/kg.

Yard-long beans. The government of Thailand submitted a description of the in-field aspects of trials on yard-long beans but included no residue data. The Meeting took no action.

Carrots. The government of The Netherlands reported six field trials with at-plant application of an SC formulation to carrots. No GAP is available for The Netherlands or an EU country. The Meeting recommended withdrawal of the existing CXL (0.5 mg/kg).

Celeriac. The government of The Netherlands reported the results of one field trial with the application of an SC carbofuran formulation to celeriac. No GAP was reported and one trial is inadequate even for a very minor crop.

Potatoes. Field trials were carried out in Colombia, France, the UK and the USA. Applications according to GAP range from at-planting in Europe to banded treatment at hill-up and multiple foliar sprays in the USA. No GAP was available for Colombia, and the trials there were not evaluated. France and the UK each reported one trial in accordance with GAP. Six trials in the USA complied with the appropriate GAP, 3.4 kg ai/ha at-plant and 8 foliar applications at 1.1 kg ai/ha each, PHI 17 days. The residues in the whole tubers in the eight trials were <0.01 (3), <0.03 (2), 0.03, 0.04 and <0.05 mg/kg. The Meeting estimated a maximum residue level of 0.1 mg/kg and an STMR of 0.03 mg/kg.

Sugar beet. Field trials were carried out in France, Italy, Germany, the UK and the USA. European GAP specifies 2 kg ai/ha at planting, and US GAP early post-emergence foliar treatment (2.2 kg ai/ha, 90-day PHI). Five trials were at the maximum GAP rate and minimum PHI. The residues on the foliage were <0.01 (3), 0.05 and 0.15 mg/kg and in the roots <0.01 (4) mg/kg. The data were insufficient to estimate a maximum residue level. The Meeting recommended withdrawal of the existing CXLs for sugar beet and sugar beet leaves or tops.

Turnips. Five field trials on the application of carbofuran to turnips in France, the UK and Norway were reported. No information on GAP was available, and the Meeting could take no action.

Celery. In two field trials in The Netherlands carbofuran was applied to the soil immediately before planting. The Meeting could not estimate a maximum residue level.

Cereal grains

Maize. Reports of trials in Brazil, France, Germany and the USA were submitted. The trials represented a combination of at-planting (France, USA, Germany) and foliar (USA, Brazil) treatments. The reports from Brazil, France, and Germany were abbreviated summaries and did not provide the detail required to evaluate the trials. The results were not used in attempting to estimate a maximum residue level and an STMR.

Eleven trials were conducted in the USA, but only two residues in silage were from trials according to current GAP. In the trials with at-plant applications the rate was 34% higher than the GAP rate and a granular formulation was used in place of the specified soluble concentrate. All the samples of forage, fodder and grain were harvested well outside the GAP PHI (>30% deviation). The two silage residues (1.1 and 1.2 mg/kg) were insufficient to estimate a maximum residue level or an STMR, nor could the Meeting estimate maximum residue levels for maize, maize fodder or maize forage It therefore recommended withdrawal of the CXLs for maize and maize fodder.

Oats. Field trials on 3 varieties at one location were reported from Germany. The treatment was at-planting, and no residues (<0.10 mg/kg) were found in the oats. The number of trials was inadequate and the report consisted of a short summary that lacked the detail required for evaluation. The Meeting recommended withdrawal of the existing CXL (0.1* mg/kg).

Rice. Field trials in Australia, Brazil, Japan, the Philippines, and the USA were reported. The Brazilian summary report lacked the detail needed to evaluate the trials. The trials in the USA, Japan, and Philippines were not according to GAP. Only one trial in Australia accorded with GAP. The Meeting recommended withdrawal of the existing CXL (0.2 mg/kg).

Sorghum. See Sorghum forage etc., below.

Wheat. Field trials in South Africa and the USA were reported. Information on GAP was not available for the at-plant trials in South Africa. The six US trials were at the maximum GAP rate, with two foliar treatments and a 21-day PHI. The total carbamate residues in the grain in rank order were 0.02, 0.02 and 0.04 (4) mg/kg. The Meeting concluded that six trials were insufficient to estimate a maximum residue level and recommended withdrawal of the existing CXL (0.1* mg/kg).

Other crops

Sugar cane. Supervised field trials with the application of carbofuran to sugar cane were carried out in Brazil and the USA. In Brazil, the carbofuran (G or SC) was applied as a soil treatment about 5 months after planting. The PHI was 90 days. No residues were found (<0.1 mg/kg) in the four trials, two of which complied with GAP and two were at twice the GAP rate. In five trials in three states of the USA with the 4F formulation an in-furrow application at planting (1.1 kg ai/ha) was followed by two aerial foliar applications (2 x 0.84 kg ai/ha), with a 30-day PHI. This was according to GAP, and the maximum carbofuran residue was 0.06 mg/kg. The Meeting estimated a maximum residue level of 0.1* mg/kg, the existing CXL and the practical limit of quantification, and an STMR of 0.1 mg/kg.

Oilseed (cotton, sunflower, peanut, rape). Field trials in the USA and Brazil on cotton were reported, and the sponsor stated that trials were now in progress in southern Europe. The trials in Brazil were with seed treatment or a single post-emergence foliar treatment (2.1 kg ai/ha, 45-day PHI). The US trials involved two foliar applications of a flowable formulation (2 x 0.28 kg ai/ha). Neither set of trials complied with the relevant GAP, which is for at-plant use in both countries.

Trials on peanuts in Brazil and the USA were reported. The government of Thailand submitted information on field trials but no data on residues. Carbofuran was applied to peanut plants in two trials in Brazil as a foliar spray (1.75 or 3 kg ai/ha) with a 14-day PHI. In 14 US trials, peanut fields were treated at pegging. In some cases an initial treatment was also made at planting. The maximum carbamate residue was 0.53 mg/kg. Most of the US trials (80%) showed no quantifiable residues. GAP in Brazil is for at-plant treatment, and the USA has no GAP for the use of carbofuran on peanuts. Neither the Brazilian nor the US results could be used to estimate a maximum residue level.

Field trials on rape (canola) were carried out in Canada (seed treatment, at-plant, post-emergence) and France (at-plant). No GAP was reported for Canada or France, and the Canadian trials did not comply with US GAP. The trials could not be evaluated.

Field trials on sunflowers were carried out in Canada, France and the USA. The trials in France were discounted, because the method of analysis was described as semi-quantitative and was not explained. The US trials were not according to GAP; the PHI was >150% of the GAP PHI of 28 days, and the at-plant application was below the maximum rate. Six trials in Canada complied with maximum US GAP and all the residues were 0.04 mg/kg. The Meeting estimated a maximum residue level for sunflower seed of 0.1* mg/kg and an STMR of 0.1 mg/kg, but concluded that the trials were inadequate to support an MRL for oilseed and recommended withdrawal of the existing CXL (0.1* mg/kg).

Coffee. Two field trials in Brazil and four in the USA, all according to national GAP, on the application of carbofuran to coffee bushes were reported. The use patterns are quite similar in both countries. GAP in Brazil specifies 0.35 g ai/tree of SC formulation or 0.5-3 g ai/tree of G formulation, and US GAP specifies two applications of 1.7 g ai/tree, 10 G formulation. The residues in rank order were 0.02 (3), 0.08, 0.12 and 0.79 mg/kg (n = 6). The Meeting estimated a maximum residue level of 1 mg/kg and an STMR of 0.10 mg/kg. The two Brazilian residues of 0.02 mg/kg were not used for the estimation of the STMR because the analysis did not include a hydrolysis step to release conjugated 3-hydroxycarbofuran.

Alfalfa. Three field trials in each of seven states in the USA were according to the current maximum use rate and minimum PHI. Green forage and fodder were analysed. The carbamate residues in the fodder ranged from the limit of detection (<0.1 mg/kg) to 7.6 mg/kg. The trials involved foliar application of a flowable formulation at 1.12 kg ai/ha with a 28-day PHI. The maximum residues of carbofuran plus 3-hydroxycarbofuran in each trial in rank order were <0.1 (2), 0.28, 0.32, 0.64, 0.74, 0.87, 0.90, 0.92, 1.2, 1.4, 1.5, 1.6, 2.6, 2.8, 3.0, 3.4, 3.8, 4.2, 4.5, 4.6, 4.7, 5.2 and 7.6 mg/kg (n = 24). The Meeting estimated a maximum residue level of 10 mg/kg and an STMR of 1.6 mg/kg. The residues in the green forage in rank order were <0.1 (5), 0.13, 0.29, 0.30, 0.34, 0.38, 0.52, 0.92, 0.9 4, 1.2 (3), 1.3, 1.4, 1.6 (2), 1.7, 1.8, 2.2 and 4.3 mg/kg (n = 24). The Meeting estimated a maximum residue level of 10 mg/kg and an STMR of 0.93 mg/kg.

Sorghum forage (green), sorghum straw and fodder, dry . Six trials in India and six in the USA were reported. The trials in India were with seed treatment or at-plant treatment, whereas the US trials were at-plant plus two foliar applications, with a total rate of 2.3 kg ai/ha. GAP was not available for India or a neighbouring country. In the US trials the residues in rank order were 0.055 (6), 0.06, 0.07, 0.11 (2), 0.13, 0.19, 0.26 and 1.2 mg/kg (n = 14) in sorghum forage (green), 0.05 (2), 0.06 and 0.20 mg/kg (n = 4) in sorghum fodder, and <0.01 (5) mg/kg in sorghum grain. The Meeting estimated maximum residue levels of 2 mg/kg for forage, 0.5 mg/kg for fodder, and 0.1* mg/kg for grain, with respective STMRs of 0.065 mg/kg, 0.055 mg/kg and 0.01 mg/kg. Although no residues were found in the grain at an estimated limit of detection of 0.01 mg/kg, the practical limit of quantification for carbofuran and 3-hydroxycarbofuran individually in plant commodities is 0.1 mg/kg.

Barley, egg plant, hops (dry), mustard seeds, peaches, pears. No trials were reported. The Meeting recommended withdrawal of the existing CXLs.

Feeding studies on poultry and cows were reported. The poultry study was defective because although residues were reported as <0.05 mg/kg from feeding 5 ppm in the diet, the uncertainties surrounding the method of analysis cast doubts on the reliability of the results. A study conducted over 7 days at 25 ppm however showed negligible concentrations of radiolabelled residue (<0.01 mg/kg as carbofuran) in muscle and fat and a residue of 0.15 mg/kg in eggs, of which the carbamate content was below 20%. Potential poultry feed items include small grain (maize, barley, oats, wheat, sorghum, 80% of the diet) and alfalfa meal (10% of the diet). Thus, the diet might contain 80% x the 0.04 mg/kg STMR of maize + 10% x the 1.2 mg/kg STMR of alfalfa hay = 0.15 mg/kg. Note that this includes a commodity (maize) for which the withdrawal of a CXL has been recommended. Residues of carbofuran and its carbamate metabolites in poultry commodities are unlikely from such feeding levels. The Meeting concluded that MRLs are not needed for poultry commodities.

The ruminant feeding study was conducted with carbosulfan, not carbofuran. Carbosulfan is metabolized rapidly to carbofuran in ruminants, and the carbofuran is converted to 3-hydroxycarbofuran and phenol metabolites. Goats were fed carbosulfan at a level of 50 ppm in the diet for 28 days. The milk contained no detectable residues of carbosulfan on days 1-4, but it was present at very low concentrations, 0.005-0.011 mg/kg, from days 7 to 27. Carbofuran was detected on day 4 at a maximum concentration of 0.006 mg/kg and on day 7 at a maximum of 0.008 mg/kg. The carbofuran metabolite 3-hydroxycarbofuran appeared on day 1 (0.022 mg/kg) and continued through day 27 (0.013 mg/kg). The tissues contained no detectable residues of carbosulfan or carbofuran, but 0.060 mg/kg of 3-hydroxycarbofuran was found in the liver and 0.13 mg/kg in kidney. The Meeting concluded that feeding with carbosulfan may be substituted for feeding with carbofuran.

The study of metabolism in goats, conducted for 7 consecutive days with 25 ppm carbofuran in the feed, revealed no radiolabelled residues (<0.01 mg/kg as carbofuran) in the muscles or fat. Significant residues occurred in the milk (0.14 mg/kg) and in the liver and kidneys (0.11, 0.18 mg/kg). About 50% of the TRR in the milk was shown not to include carbamate compounds, and about 11% was carbofuran plus 3-hydroxycarbofuran (0.02 mg/kg). The kidneys and liver each contained <15% carbamates (0.02 mg/kg).

On the basis of the MRLs recommended by the present Meeting, the ruminant diet would contain no more than 2 mg/kg of carbofuran plus 3-hydroxycarbofuran. This is based on a diet containing 80% of alfalfa fodder (0.8 x the STMR of 1.6 mg/kg = 1.3 mg/kg). Owing to the substantial number of MRLs recommended for withdrawal there are few animal feed items. The Meeting estimated a maximum residue level of 0.05* mg/kg and an STMR of 0.05 mg/kg for residues (as defined above) in various animal products and milks.

Processing

Studies were conducted with sorghum, sugar beet, potatoes, maize, rice, sunflowers, cotton seed, sugar cane, coffee, pimento peppers, and grapes. Most of them were of limited value because the raw agricultural commodities contained carbamate residues below the limit of detection or between the limit of detection and the limit of determination. In most cases the same applied to the processed commodities. On the basis of the recommendations of the Meeting, processing studies would be appropriate for coffee, potatoes, sunflowers, and sugar cane. The sugar cane and potato processing studies, with applications at 1.8 times and twice the GAP rate respectively, were inadequate because there were no residues in the raw agricultural commodities. The sunflower processing study was acceptable: the residue was unchanged in the edible oil and increased in the hulls and extracted meal by factors of 1.2 and 1.8 respectively. The coffee processing study showed a reduction factor of approximately 0.05-fold for instant and roast coffee. The value is approximate because the residues in the processed commodities were at the limit of detection.

RECOMMENDATIONS[AFM1]

The Meeting estimated the maximum residues and STMR residues listed below. The maximum residue levels are recommended for use as MRLs.

Pesticide (Codex ref. No.)	ADI (mg/kg bw)	Commodity CCN	Recommended MRL or ERL (mg/kg)		STMR (mg/kg)	
			Name	New	Previous	New
Carbofuran**	0.002	AL 1020	Alfalfa fodder	10	20	1.6
(096)		AL 1021	Alfalfa forage (green)	10	5	0.93
		FI 0327	Banana	0.1*	0.1*	0.1
		GC 0640	Barley	W	0.1*	
		VB 0402	Brussels sprouts	W	2	
		VB 0041	Cabbages, Head	W	0.5	
		VC 4199	Cantaloupe	0.2	-	0.02
		VR 0577	Carrot	W	0.5	
		MF 0812	Cattle fat	0.05*	0.05*	0.05

Pesticide (Codex ref. No.)	ADI (mg/kg bw)	Commodity CCN	Recommended MRL or ERL (mg/kg)		STMR (mg/kg)	
			Name	New	Previous	New
		VB 0404	Cauliflower	W	0.2	
		DM 0001	Citrus molasses[1]			0.11 P
		AB 0001	Citrus pulp, dry[1]	2	-	0.29
		SB 0716	Coffee beans	1	0.1*	0.1
			Coffee, Instant			0.005 P[1]
		SM 0716	Coffee, Roast			0.005 P
		VC 0424	Cucumber	0.3	-	0.05
		MO 0096	Edible offal of cattle, goats, horses, pigs and sheep	0.05*	0.05*	0.05
		VO 0440	Egg plant	W	0.1*	
		MF 0814	Goat fat	0.05*	0.05*	0.05
		DH 1100	Hops, dry	W	5	
		MF 0816	Horse fat	0.05*	0.05*	0.05
		VB 0405	Kohlrabi	W	0.1*	
		VL 0482	Lettuce, Head	W	0.1*	
		GC 0645	Maize	W	0.1*	
		AS 0645	Maize fodder	W	5	
		MM 0096	Meat of cattle, goats, horses, pigs and sheep	0.05*	0.05*	0.05
		ML 0106	Milks	0.05*	0.05*	0.05
		SO 0090	Mustard seed	W	0.1*	
		GC 0647	Oats	W	0.1*	
		SO 0088	Oilseed	W	0.1*	
		VA 0385	Onion, Bulb	W	0.1*	
		FC 0004	Oranges, Sweet, Sour[1]	0.5	-	0.1
		JF 0004	Orange juice[1]			0.001
		FS 0247	Peach	W	0.1*	
		FP 0230	Pear	W	0.1*	
		MF 0818	Pig fat	0.05*	0.05*	0.05
		VR 0589	Potato	0.1	0.5	0.03
		CM 0649	Rice, Husked	W	0.2	
		MF 0822	Sheep fat	0.05*	0.05*	0.05
		GC 0651	Sorghum	0.1*	0.1*	0.01
		AF 0651	Sorghum forage (green)	2	-	0.065
		AS 0651	Sorghum straw and fodder, dry	0.5	-	0.055
		VD 0541	Soya bean, dry	W	0.2	
		VC 0431	Squash, Summer	0.3	-	0.05
		FB 0275	Strawberry	W	0.1*	
		VR 0596	Sugar beet	W	0.1*	
		AV 0596	Sugar beet leaves or tops	W	0.2	
		GS 0659	Sugar cane	0.1*	0.1*	0.1
		SO 0702	Sunflower seed	0.1*	0.1*[2]	0.1
		VO 1275	Sweet corn (kernels)	W	0.1*	
		VO 0447	Sweet corn (corn-on-the -cob)	0.1	-	0.03
		VO 0448	Tomato	W	0.1*	

Pesticide (Codex ref. No.)	ADI (mg/kg bw)	Commodity CCN	Recommended MRL or ERL (mg/kg)		STMR (mg/kg)	
			Name	New	Previous	New
		GC 0654	Wheat	W	0.1*	

FURTHER WORK OR INFORMATION

Desirable

1. A feeding study with cows fed carbofuran.

2. Processing studies on potatoes and sugar cane. Exaggerated treatment rates (five- to tenfold) should be used to obtain weathered residues in or on the raw agricultural commodities.

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[AFM1]Table is from Annex I so needs editing. Text also needed.