The Connecticut Agricultural Experiment Station, New Haven

Pesticide Residues in Produce Sold in Connecticut 1990

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SUMMARY

Of the 436 samples of produce tested in 1990, 265 samples (61%) contained pesticide residues. None of the 436 samples contained residues above allowable tolerances, but three samples (0.7%) contained residues for which no EPA tolerance exists for that product. Sixty-two of the 436 samples tested were labeled as "organically grown" and eight of those samples (12.9%) contained pesticide residues. For the produce samples tested in 1990 there was a 12% increase in pesticide residues as compared to produce tested in 1989. The analyses reported in this Bulletin and earlier data suggest that pesticide residues on produce sold in Connecticut are generally well below EPA tolerances.

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The Environmental Protection Agency (EPA) registers all pesticides in the United States and approves their use on specific agricultural crops. The residues of pesticides that remain in or on the produce after harvest must be below allowable tolerances (Code of Federal Regulations, 1990). Analytical testing is performed at this Station to determine if pesticides are present in products sold in Connecticut and whether the concentrations found are within the EPA tolerances. Results of all tests are forwarded to the Connecticut Department of Consumer Protection, which has the regulatory responsibility for enforcement of pesticide tolerances. These tests assure consumers that produce sold in this state meets EPA pesticide tolerance levels.

In accordance with the Charter of this Station to report results of analyses, we now present information on pesticide residues in produce sold in Connecticut in 1990 (General Statutes, 1989).

METHODS

Produce was collected at farms, roadside stands, and food stores by inspectors of the Connecticut Department of Consumer Protection and delivered to the laboratory within 24 hours of collection.

Products were tested for pesticide residues by official and recommended methods known as multi-residue methods (Pesticide Analytical Manual, 1968; Luke et al, 1981) and by single residue methods (Pease, 1957; Conditt et al, 1988; Bushway et al, 1990). The basic principle of a multi-residue method is the analysis for a selected group of pesticides using the combined techniques of extraction and cleanup, followed by compound separation and quantitation by capillary gas chromatography. This has been described in more detail by Pylypiw (1989) and Hankin (1988).

Several single residue methods were used this year to test selected commodities for fungicides known as Ethylene-Bis-Dithio-Carbamates (EBDCs) (Pease, 1957), the plant growth regulator Alar (Conditt et al, 1988), and the fungicide Benomyl (Bushway et al, 1990). Samples analyzed by a single residue method provide only one determination for each individual test. Multi-residue methods, however, can provide simultaneous determination of up to 80 different pesticides and metabolites. The methods used to test our samples have a detection limit of 0.002 parts-per-million (ppm).

RESULTS AND DISCUSSION

In 1990, a total of 436 samples representing 73 different varieties and types of produce were tested for pesticide residues. Concentrations of the residues found are given in Table 1. Pesticide residues were found in 265 samples (61%). None of the samples contained residues above EPA tolerance allowances, but three samples (0.7%) contained residues for which no EPA tolerance exists for that product. The fungicide Bravo and the insecticide/acaricide Thiodan were found on two samples of beets. The fungicide Iprodione was found on one sample of bosc pears. Bravo, Thiodan and Iprodione are, however, registered for use on other crops.

Twenty-eight samples (6.4%) consisting of root crops, (beets and carrots) and above ground crops (cantaloupe, cabbage, cucumbers, eggplant, kale, bell-peppers, spinach, and squash) contained traces of BHC, Chlordane, DDE, Dieldrin, and Heptachlor Epoxide. These materials, no longer in agricultural use, had been used on crops many years ago and have persisted in the soil. Although the EPA tolerance on these compounds is zero, the Food and Drug Administration (FDA) recognizes their persistence in the environment and has set action levels (allowable amounts) for these compounds in fruits, vegetables, and other commodities (Compliance Policy Guides, 1986).

The environmental persistence of DDT has been tested at this Station. Green squash was grown in soil that contained less than 1 ppm DDT and its metabolites DDE and TDE. The plants produced fruit containing an

average of 0.006 ppm DDE and 0.001 ppm TDE. DDT had not been used in these plots since 1972 (Pylypiw et al, 1991).

Table 2 lists all pesticides that were found in the commodities tested, synonyms if available, their use, and their frequency of occurrence. Benomyl was the most frequently detected residue followed by Thiodan, Guthion, Dursban, Imidan, Ronalin, Captan, DDE, and Kelthane. Only apples, apple cider and strawberries were tested for Benomyl and these comprised over 52% of the samples tested. In many cases more than one residue was found on the same crop. Sixty-nine samples contained two different pesticide residues each, 43 contained three different residues each, five contained four different residues each, and two contained five residues each.

Table 3 lists the number and source of the samples. Overall, 69.5% of the samples were from Connecticut farms and orchards, 21.1% from other states and 9.4% from foreign countries. Produce from foreign countries included pears from Argentina, Australia and New Zealand; oranges and tomatoes from Israel; ugli fruit from Jamaica; pineapple from Costa Rica; and table grapes from Chile. Produce grown in other states included carrots and broccoli from California; banana peppers from Florida; potatoes from Idaho; spinach from New York and Massachusetts; mushrooms from Pennsylvania; and apples from New York, Washington, Pennsylvania, Massachusetts, and Vermont.

Sixty-two samples of produce labeled as "organically grown" were also tested and shown in Table 1. Eight of the samples (12.9%), cabbage, cantaloupe, carrots and squash, contained traces of Chlordane, DDE, and Heptachlor Epoxide, which are considered unavoidable pesticides (Compliance Policy Guides, 1986).

We compared the data obtained in our 1990 study to data obtained in 1989. The same eight commodities, apples, apple cider, carrots, corn, bell-peppers, green and yellow squash, strawberries, and tomatoes were selected for comparison. In 1990, as in 1989, there was an increase in detectable residues on apple products. These changes included a 15.1% increase on apples and a 22.3% increase in apple cider. These increases were primarily due to increased testing since 1989 for Benomyl and EBDCs on these products.

Specifically, the fungicide Benomyl was found 128 times (85%) in 150 samples of apples and apple cider. EBDC fungicides were found 13 times (52%) in 25 samples of apples. In 1990 we tested 14 samples of apples from other states for the growth regulator Alar. None of the 14 samples contained detectable amounts of Alar. These tests were a follow up of tests for Alar on Connecticut-grown apples in 1989 and from a study on the carry-over of Alar applied to apple orchards in previous growing seasons (Mattina et al., 1990).

Other comparisons of pesticide residues found from 1989 to 1990 included a 23.6% increase on carrots, no change on corn, a 13.5% decrease on bell-peppers, a 31.4% decrease on green and yellow squash, a 28.3% increase on strawberries, and an 8.6% decrease on tomatoes.

In this study we report that 61% of the fruits and vegetables we tested contained residues. The FDA reported that 36.1% of the fruit and vegetable samples that they tested in 1989 contained pesticide residues (Food and Drug Administration, 1990). The FDA considers pesticide levels below 0.01 ppm for chlorinated pesticides and below 0.02 ppm for phosphated pesticides to be trace amounts, and thus these results are not included in their total percentage (Pesticide Analytical Manual, 1968). We report (Table 1) all pesticide concentrations found in our samples, from the highest amounts down to our detection limit of 0.002 ppm.

The geographical coverage of the samples in the FDA study is significantly different when compared to our study. About 70% of the produce we tested was grown in Connecticut, whereas the FDA obtained at most 1% of their produce from Connecticut (Food and Drug Administration, 1990). In addition, about 59% of the produce tested by the FDA was from foreign countries, while in our study, slightly over 9% of the samples were from foreign countries.

In conclusion, we noted a 12% increase in the number of pesticide residues found in produce since 1989. Most of this increase was due to changes in testing procedures which allow for the detection and determination of more pesticides. Although the number of pesticide findings increased in 1990, the number of violative findings decreased. In 1988 we found 10 violative samples, in 1989 there were 9, but only 3 in 1990. The results of our 1990 study show that pesticides found in Connecticut fruits and vegetables are generally well below established safety standards.

ACKNOWLEDGEMENTS

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Table 1. Concentrations of pesticide residues in produce sold in Connecticut in 1990. The numbers following the product name are the number of samples tested, the number of positive findings for a pesticide residue, the number of samples labeled as organic, if any, and the number of positive findings, if any. The number in parentheses following the pesticide name is the number of times that pesticide was found.

Produce Pesticide/(number)	Residue range (ppm)	EPA tolerance (ppm)
Apples, Baldwin (1 tested, 1 pos.)		
Benomyl (1)	0.012	7
Apples, Cortland (6 tested, 5 pos.)		
Benomyl (4)	0.01-0.1	7
Dursban (1)	0.005	1.5
Guthion (1)	0.02	2
Thiodan (2)	0.02-0.03	2
Apples, for Cider (5 tested, 5 pos.)		
Benomyl (5)	0.012-0.07	7
Kelthane (1)	0.11	5
Thiodan (2)	0.018-0.077	2
Apples, Empire (8 tested, 7 pos.)		
Benomyl (7)	0.011-0.15	7
Dursban (4)	0.005-0.05	1.5
EBDC (1)	3.0	7
Guthion (2)	0.04	2
Imidan (3)	0.011-0.25	10
Kelthane (2)	0.28-0.34	5
Thiodan (1)	0.012	2
Apples, Granny Smith (12 tested, 10 pos.)		
Benomyl (7)	0.029-0.4	7
Dursban (3)	0.009-0.06	1.5
EBDC (2)	0.05-0.15	7
Ethion (1)	0.05	2
Guthion (2)	0.043-0.048	2
Imidan (1)	0.106	10
Thiodan (3)	0.01-0.055	2
Apples, Idared (4 tested, 4 pos.)		
Benomyl (4)	0.012-0.043	7
Guthion (1)	0.06	2
Thiodan (1)	0.03	2
Apples, Macoun (6 tested, 6 pos.)		
Benomyl (6)	0.014-0.105	7
Dursban (1)	0.034	1.5
Guthion (1)	0.032	2
Imidan (1)	0.018	10
Apples, Matsu-Crispin (1 tested, 1 pos.)		
Benomyl (1)	0.085	7
Dursban (1)	0.03	1.5
Kelthane (1)	0.12	5

Table 1. (Continued)

Produce Pesticide/(number)	Residue range (ppm)	EPA tolerance (ppm)
Apples, McIntosh (30 tested, 29 pos.)		
Benomyl (25)	0.011-0.2	7
Dursban (9)	0.003-0.15	1.5
EBDC (5)	0.05-2.5	7
Guthion (5)	0.015-0.15	2
Imidan (8)	0.01-0.05	10
Kelthane (4)	0.15-0.44	5
Penncap-M (2)	0.01-0.028	1
Thiodan (3)	0.01-0.035	2
Apples, Red Delicious (20 tested, 17 pos.)(1 organic)		
Benomyl (16)	0.01-0.38	7
Dursban (1)	0.031	1.5
EBDC (1)	1.5	7
Guthion (1)	0.022	2
Imidan (4)	0.04-0.22	10
Kelthane (6)	0.076-0.3	5
Thiodan (5)	0.015-0.17	2
Apples, Rome (3 tested, 3 pos.)		
Benomyl (3)	0.23-0.45	7
Dursban (1)	0.10	1.5
EBDC (3)	0.05-0.36	7
Guthion (1)	0.2	2
Kelthane (1)	0.067	5
Apples, Spartan (1 tested, 1 pos.)		
Benomyl (1)	0.083	7
Apples, Winesap (2 tested, 2 pos.)		
Benomyl (2)	0.145-0.16	7
Dursban (2)	0.03-0.45	1.5
Apples, Yellow Delicious (3 tested, 3 pos.)		
Benomyl (2)	0.04-0.15	7
Dursban (1)	0.08	1.5
EBDC (1)	0.9	7
Ethion (1)	0.2	2
Guthion (3)	0.027-0.26	2
Thiodan (1)	0.005	2
Apricots, Dried (2 tested, 0 pos.)(1 organic)		
Banana, Chips (1 tested, 0 pos.)		
Beans, Green-Snap (1 tested, 0 pos.)		
Beans, Purple-Snap (1 tested, 0 pos.)(1 organic)		

Table 1. (Continued)

Produce Pesticide/(number)	Residue range (ppm)	EPA tolerance (ppm)
Beets, Root (4 tested, 3 pos.)		
Bravo (2)**	0.005-0.06	0
DDE (1)	0.002	0
Malathion (1)	0.25	8
Thiodan (2)**	0.01	0
Blueberries (1 tested, 1 pos.)		
Captan (1)	0.05	25
Broccoli (5 tested, 0 pos.)(2 organic)		
Cabbage, Chinese (1 tested, 0 pos.)(1 organic)		
Cabbage, Green (3 tested, 1 pos.)(3 organic, 1 pos.)		
Heptachlor Epoxide (1)*	0.017	0
Cabbage, Savoy (1 tested, 0 pos.)(1 organic)		
Cantaloupe (1 tested, 1 pos.)(1 organic, 1 pos.)		
Chlordane (1)*	0.031	0
Heptachlor Epoxide (1)*	0.028	0
Carrots (15 tested, 9 pos.)(5 organic, 2 pos.)		
BHC (1)	0.02	0
Bravo (2)	0.01	1
DDE (9)*	0.004-0.60	0
Iprodione (1)	0.42	5
Celery (1 tested, 0 pos.)(1 organic)		
Cider, Apple (48 tested, 43 pos.)		
Benomyl (43)	0.01-0.093	7
Cole Slaw, Cabbage & Carrot (1 tested, 0 pos.)		
Corn, Bi-Color (17 tested, 0 pos.)		
Corn, White (7 tested, 0 pos.)(1 organic)		
Corn, Yellow (4 tested, 0 pos.)		
Cucumbers (9 tested, 6 pos.)(1 organic)		
Bravo (1)	0.024	5
DDE (1)	0.004	0
Thiodan (4)	0.009-0.032	2
Eggplant (5 tested, 2 pos.)(3 organic)		
DDE (2)	0.002-0.006	0
Thiodan (1)	0.007	2
Flour, Brown-rice (1 tested, 0 pos.)		
Grain, Rye (1 tested, 0 pos.)(1 organic)		

* --- This pesticide found in a sample labeled as organic.

** -- Violative residue.

Table 1. (Continued)

Produce Pesticide/(number)	Residue range (ppm)	EPA tolerance (ppm)
Grapes, Table-Black (3 tested, 2 pos.)		
Captan (1)	0.3	50
Ronalin (1)	0.11	6
Thiodan (1)	0.005	2
Grapes, Table-Green (6 tested, 5 pos.)(1 organic)		
Captan (5)	0.03-2.0	50
Iprodione (2)	0.42-0.5	60
Ronalin (4)	0.002-0.30	6
Grapes, Table-Red (4 tested, 4 pos.)		
Captan (4)	0.13-0.5	50
Ronalin (1)	0.13	6
Greens, Mustard (1 tested, 0 pos.)(1 organic)		
Juice, Orange (18 tested, 6 pos.)		
Dursban (1)	0.006	1
Ethion (3)	0.005-0.008	2
Guthion (2)	0.02-0.04	2
Imidan (1)	0.022	5
Kale (1 tested, 1 pos.)		
DDE (1)	0.008	0
Thiodan (1)	0.008	2
Lettuce, (2 tested, 1 pos.)(1 organic)		
Ronalin (1)	0.028	10
Melon, Honeydew (1 tested, 0 pos.)		
Mushrooms (4 tested, 3 pos.)		
Diazinon (3)	0.005-0.02	0.75
Nectarines (2 tested, 1 pos.)		
Dicloran (1)	0.4	20
Thiodan (1)	0.01	2
Oats, Rolled (1 tested, 0 pos.)		
Onions (1 tested, 0 pos.)(1 organic)		
Oranges (2 tested, 0 pos.)(1 organic)		
Peas, Pod Removed (1 tested, 0 pos.)		
Peaches (11 tested, 11 pos.)		
Bravo (1)	0.012	0.5
Captan (1)	8.0	50
Dicloran (3)	0.07-3.5	20
Dursban (1)	0.01	0.05
Guthion (4)	0.05-0.27	2
Imidan (3)	0.04-0.06	10
Iprodione (1)	0.7	20
Thiodan (5)	0.01-1.7	2

Table 1. (Continued)

Produce Pesticide/(number)	Residue range (ppm)	EPA tolerance (ppm)
Pears, Bartlett (3 tested, 2 pos.)		
Imidan (1)	0.08	10
Kelthane (1)	0.087	5
Pears, Bosc (6 tested, 6 pos.)		
Benomyl (1)	0.08	7
Captan (1)	0.17	25
Dursban (1)	0.006	0.05
Guthion (4)	0.04-0.25	2
Imidan (1)	0.45	10
Iprodione (1)**	0.14	0
Thiodan (1)	0.2	2
Peppers, Green-Banana (3 tested, 0 pos.)		
Peppers, Green-Bell (16 tested, 4 pos.)(6 organic)		
Dacthal (1)	0.01	2
DDE (1)	0.09	0
Guthion (1)	0.28	0.3
Thiodan (2)	0.025-0.06	2
Pineapple (1 tested, 0 pos.)		
Pineapple, Dried (1 tested, 0 pos.)		
Plums (1 tested, 1 pos.)		
Iprodione (1)	0.14	20
Potatoes (4 tested, 0 pos.)(1 organic)		
Radishes (1 tested, 0 pos.)(1 organic)		
Raisins (1 tested, 0 pos.)(1 organic)		
Raspberries, Red (1 tested, 0 pos.)(1 organic)		
Raspberries, Yellow (1 tested, 0 pos.)(1 organic)		
Spinach (3 tested, 3 pos.)		
DDE (3)	0.002-0.02	0
Guthion (1)	0.03	2
Thiodan (2)	0.015-0.03	2
Squash, Acorn (3 tested, 0 pos.)(2 organic)		
Squash, Butternut (2 tested, 1 pos.)(1 organic)		
Malathion (1)	0.03	8
Squash, Italian-Delicata (1 tested, 0 pos.)(1 organic)		

** -- Violative residue.

Table 1. (Continued)

Produce Pesticide/(number)	Residue range (ppm)	EPA tolerance (ppm)
Squash, Green (14 tested, 5 pos.)(6 organic, 3 pos.)		
Captan (1)	0.4	25
Chlordane (3)*	0.004-0.03	0
Dieldrin (1)	0.015	0
Heptachlor Epoxide (3)*	0.012-0.025	0
Squash, Yellow (16 tested, 7 pos.)(1 organic, 1 pos.)		
Captan (2)	0.03-0.2	25
Chlordane (1)*	0.015	0
Dacthal (1)	0.01	1
DDE (2)	0.003-0.004	0
Heptachlor Epoxide (1)*	0.007	0
Thiodan (5)	0.010-0.035	2
Strawberries (41 tested, 37 pos.)		
Benomyl (32)	0.012-2.0	5
Captan (5)	0.04-0.38	25
Dacthal (3)	0.015-0.07	2
Dursban (2)	0.002-0.015	0.5
Guthion (4)	0.01-0.04	2
Kelthane (1)	0.22	5
Ronalin (16)	0.005-0.9	10
Thiodan (14)	0.007-0.075	2
Swiss Chard (1 tested, 0 pos.)(1 organic)		
Tomatoes (25 tested, 5 pos.)(11 organic)		
Bravo (2)	0.01-0.45	5
Thiodan (3)	0.047-0.25	2
Ugli Fruit (1 tested, 0 pos.)		

* --- This pesticide found in a sample labeled as organic.

Table 2. Pesticides found, agricultural use, total findings, and frequency of occurrence.

Common name	Synonym	Use (a)	Total No. of Findings (b)	Percent Occurrence
Benomyl (c)	Benlate	F	160	36.7
BHC (d)	Benzenehexachloride	I	1	0.2
Bravo	Chlorthalonil	F	8	1.8
Captan		F	21	4.8
Chlordane (d)		I	5	1.1
Dacthal	DCPA	H	5	1.1
DDE (d,e)		I	20	4.6
Diazinon		I,N	3	0.7
Dicloran	DCNA	F	4	0.9
Dieldrin (d)		I	1	0.2
Dursban	Chlorpyrifos	I	29	6.7
EBDC (f)		F	13	3.0
Ethion		I,A	5	1.1
Guthion	Azinophos-methyl	I	33	7.6
Heptachlor Epoxide (d,g)		I	6	1.4
Imidan	Phosmet	I	23	5.3
Iprodione	Rovral	F	6	1.4
Kelthane	Dicofol	A	17	3.9
Malathion		I	2	0.5
Penncap-M	Methyl Parathion	I	2	0.5
Ronalin	Vinclozolin	F	23	5.3
Thiodan	Endosulfan	I,A	60	13.8

(a) From Farm Chemical Handbook (1989), 75th edition. Meister Publishing Co., Willoughby, OH 44094
A= Acaricide, F= Fungicide, H= Herbicide, I= Insecticide, N= Nematocide.

(b) Based on 436 items.

(c) Reflects overall incidence but only apple, apple cider and strawberry samples were selected for Benomyl analysis.

(d) No longer in agricultural use.

(e) Metabolite of DDT.

(f) Reflects overall incidence but only 25 apple and 3 corn samples were selected for EBDC analysis.

(g) Metabolite of Heptachlor.

Table 3. Source of produce tested in 1990.

Produce	Connecticut	U.S.	Foreign	Total
Apples	67	29	6	102
Apricots, Dried	0	2	0	2
Banana, Chips	0	0	1	1
Beans, Snap	2	0	0	2
Beets, Root	4	0	0	4
Blueberries	1	0	0	1
Broccoli	2	3	0	5
Cabbage	5	0	0	5
Cantaloupe	1	0	0	1
Carrots	1	13	1	15
Celery	0	1	0	1
Cider, Apple	48	0	0	48
Cole Slaw	0	1	0	1
Corn	25	3	0	28
Cucumbers	8	1	0	9
Eggplant	5	0	0	5
Flour, Brown-Rice	0	1	0	1
Grain, Rye	0	1	0	1
Grapes, Table	0	1	12	13
Greens, Mustard	1	0	0	1
Juice, Orange	3(a)	15(b)	0	18
Kale	0	1	0	1
Lettuce	1	1	0	2
Melon, Honeydew	0	0	1	1
Mushrooms	0	4	0	4
Nectarines	0	0	2	2
Oats, Rolled	0	1	0	1
Onions	1	0	0	1
Oranges	0	1	1	2
Peas, Pod Removed	1	0	0	1
Peaches	5	2	4	11
Pears	1	1	7	9
Peppers	17	2	0	19
Pineapple	0	0	2	2
Plums	0	0	1	1
Potatoes	2	2	0	4
Radishes	1	0	0	1
Raisin	0	1	0	1
Raspberries	2	0	0	2
Spinach	0	3	0	3
Squash, Winter	5	0	0	5
Squash, Summer	31	0	0	31
Strawberries	41	0	0	41
Swiss Chard	0	1	0	1
Tomatoes	22	1	2	25
Ugli Fruit	0	0	1	1
TOTALS	303	92	41	436

(a) Orange juice listed as Connecticut were from oranges squeezed in the state.

(b) Orange juice listed as U.S. contained juice concentrates from Florida and/or Brazil.

The Connecticut Agricultural Experiment Station, founded in 1875, is the first experiment station in America. It is chartered by the General Assembly to make scientific inquiries and experiments regarding plants and their pests, insects, soil and water, and to perform analyses for State agencies. The laboratories of the Station are in New Haven and Windsor; its Lockwood Farm is in Hamden. Single copies of bulletins are available free upon request to Publications; Box 1106; New Haven, Connecticut 06504. ISSN 0097-0905