

Effect of Selected Pesticides on Quality of Strawberries

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Effects of pesticides on composition and quality of strawberries grown on soil treated with chlordan previous to 1965 were studied. Chlordan and demeton were investigated in 1965, and captan and ferbam in 1966. Pesticides were applied in accordance with recommended procedures of the U. S. Department of Agriculture and generally had little detectable effect on compositional factors,

including sugars and acids, or on color, texture, and flavor of the fruit. No detectable residues of captan or ferbam were found on fungicide-treated fruit. Traces of demeton were found on two samples of demeton-treated fruit. One control and three chlordan-treated samples contained more than 0.3 p.p.m. of chlordan. No relationship was found between residue levels and quality of the strawberries.

The effects of pesticides on fruits and vegetables have been extensively investigated. Many investigations have had for their purpose either the determination of type and amount of pesticide residues or evaluation of any flavor change resulting from the field application of pesticides.

Tichenor *et al.* (1959) in a study of the effects of 21 insecticides and five fungicides on strawberries found no off-flavors in the frozen fruit that could be related to pesticide treatment. Murphy *et al.* (1961) reported that thiodan had no adverse effect on flavor of strawberries. However, pesticides can affect the content of acids, sugars, and possibly other constituents that might affect flavor (Beyer and Weckel, 1960; Deszyck and Ting, 1958; Garman *et al.*, 1953; Lawver and Hartz, 1965; Taylor and Mitchell, 1956). Ordas *et al.* (1956) reported that analysis of a large number of crops, including strawberries, treated with recommended dosages of chlordan showed no significant residues at harvest time, but presented no data on the amount of pesticide used on strawberries, the method of application, or the actual residue found. Duffy and Wong (1967), in a study of organochlorine insecticides and their metabolites in soils, found significant amounts in soils where organochlorine compounds had been frequently applied. Nash and Woolson (1967) reported that 40% of chlordan applied to sandy loam soil remained after 14 years.

The increasing interest in the possible effects of pesticides on food quality has made desirable further investigations in this field. This work was carried out to determine whether pesticides applied to strawberries in accordance with recommended procedures would result in significant residues or detectable effects on composition or on color and flavor as evaluated by panel.

EXPERIMENTAL

Each pesticide selected for study was representative of a specific type. Captan, a fungicide, is an enzyme poison affecting particularly enzymes containing SH groups (Owens and Novotny, 1959). The fungicide ferbam forms covalent bonds with SH groups, producing mercaptides (Owens and Novotny, 1959). Demeton, a systemic insecticide, is an enzyme inhibitor and is translocated in the

plant (Lord, 1955). Chlordan is a contact insecticide. Contact insecticides, other than chlordan, have been detected some distance from the site of entry into the plant (Finlayson and MacCarthy, 1965). This would indicate that even though an insecticide is not classed as a systemic, it may be translocated in the plant.

Work was carried out during two crop years. In 1965, chlordan and demeton were studied. The strawberry varieties used were Earlidawn, an early maturing variety, and Armore, a later maturing fruit. Work was carried out on fresh fruit and on frozen fruit stored for 1 week and 3 months at 0°F. Each variety was sampled on four different days. Duplicate determinations were carried out on each sample lot. In 1966, ferbam and captan were investigated on fresh fruit of Sunrise and Surecrop varieties.

The fruit was picked in the evening, held at about 37°F overnight, and transported to the laboratory the following morning. In 1965, samples of the whole berries were frozen without added sugar and stored at 0°F until tested.

Data were evaluated by analysis of variance (Snedecor, 1956). Differences between means were tested for significance by application of Student's *t* test.

METHODS

Production. The strawberries were grown on a farm near Germantown, Md., on plots treated with chlordan in 1964. Chlordan and demeton were applied as emulsifiable concentrates in accordance with recommendations of the Entomology Research Division, U. S. Department of Agriculture (1964). The fruit receiving demeton was sprayed in late April and again 2 weeks later, with $\frac{3}{4}$ pound of active material per acre per application. For the chlordan treatment, the insecticide was applied to the soil in late April at a level of 1 pound of active material per acre. Captan and ferbam were applied as wettable powders as recommended by the Crops Research Division, U. S. Department of Agriculture (McGrew, 1963). Captan was applied at the rate of 1.9 pounds per acre at early bloom and again at late bloom, and ferbam at the rate of 3 pounds per acre, 14 days before harvest. Control strawberries received no insecticide or fungicide treatment. The strawberries were separated by buffer strips to prevent contamination by drifting spray.

Determinations. Possible changes in carbohydrate metabolism were evaluated by determination of titratable acids, pH, citric, malic, and ascorbic acids, glucose, fructose, sucrose, and soluble solids. Texture was

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Table I. Effect of Chloridan and Demeton on Quality of Strawberries

Variety	Treatment	Malic ^a Acid, Mg./100 G.	Citric Acid, Mg./100 G.	Titratable Acid, % (as Citric)	pH	Soluble Solids, %	Fructose, %		Glucose, %		Sucrose, %		Ascorbic Acid, Mg./100 G.	Shear, ^b Cm.	Color Difference ^c Meter		Texture ^e	Natural Flavor	Off-flavor
							%	%	%	%	L	^a F							
Earlidawn (fresh)	Control	187a	703	0.90	3.26	6.3	1.66	1.44	0.39	61.1	19.6	22.9	9.8	5.86	4.6	4.0	4.4	4.2	
	Chloridan	170b	706	0.89	3.28	6.0	1.52	1.38	0.35	56.3	19.2	24.0	10.0	5.78	4.7	4.1	4.4	4.5	
	Demeton	170b	705	0.90	3.29	6.0	1.41	1.33	0.36	57.2	20.0	24.6	10.7	5.68	4.4	4.1	4.2	4.1	
Armore (fresh)	Control	129a	492	0.57	3.52	7.9	2.13	1.75	0.90	51.1	16.0	20.1	7.5	4.72	4.2	4.2	4.4	4.0	
	Demeton	90b	509	0.59	3.55	7.2	2.20	1.75	0.75	48.7	19.3	18.6	9.2	5.15	4.6	4.1	4.4	4.2	

^a Means having different letters are significantly different at 5% level.

^b Area under curve representing shearing force.

^c L indicates lightness, ^aF, redness, and ^bF, yellowness.

^d Scale ranged from 5, bright natural red, to 1, extremely dull, faded, or dark.

^e Scale ranged from 7, very soft, to 1, very hard or tough, 4 being optimum.

^f Scale ranged from 5, pronounced full flavor, to 1, lacking in flavor.

^g Scale ranged from 5, no off-flavor, to 1, very strong off-flavor.

Table II. Effect of Ferbam and Captan on Quality Factors of Two Strawberry Varieties

Variety	Treatment	Malic Acid, Mg./100 G.	Citric Acid, Mg./100 G.	Titratable Acid, % (as Citric)	pH	Soluble Solids, %	Fructose, %	Glucose, %	Sucrose, %	Ascorbic Acid, Mg./100 G.	DH + DK ^{a,b} , Mg./100 G.	Alcohol-insoluble Solids, %	Total Solids, %	Total Pectin, %	Proto-pectin, %	Water-soluble Pectin, %
Surecrop	Control	219	544	0.83	3.36	7.0	1.82	1.72	0.47	59.6	6.1b	2.28	8.37	3.46	2.23	1.19
	Ferbam	244	647	0.94	3.41	6.8	1.88	1.79	0.73	64.6	7.8a	2.25	8.80	3.43	1.85	1.58
	Captan	199	551	0.90	3.40	6.9	2.03	1.93	0.75	62.4	5.4b	2.26	9.10	3.61	2.16	1.45
Sunrise	Control	118	810	0.96	3.44	7.6	2.52	2.50	0.94	57.7	6.9a	1.93a	9.84	2.96	1.90	1.05
	Ferbam	102	705	0.96	3.45	7.1	2.58	2.31	1.17	56.6	6.2b	1.93a	9.49	3.09	1.98	1.11
	Captan	125	861	0.90	3.43	7.8	2.17	2.09	0.91	48.3	6.0b	1.70b	9.14	3.25	2.13	0.91

^a Means having different letters are significantly different at 5% level.

^b Dehydroascorbic acid + diketogluconic acid.

Table III. Effect of Ferbam and Captan on Color, Texture, and Flavor of Two Strawberry Varieties

Variety	Treatment	Color Difference Meter		Panel Scores for Off-flavor		Texture	Shear, Sq. Cm.
		L	^a F	Flavor	Texture		
Surecrop	Control	18.4	21.0	8.9	4.0	5.3	3.80
	Ferbam	19.4	21.7	9.4	4.1	4.9	4.15
	Captan	18.4	22.5	9.2	4.0	5.0	4.01
Sunrise	Control	21.5	26.9	11.2	3.9	4.9	3.86
	Ferbam	23.4	28.1	12.3	4.0	5.0	3.91
	Captan	22.5	27.3	11.5	3.9	4.9	3.82

measured by shear press and color by color difference meter. In addition, panel evaluations of flavor, off-flavor, color, and texture were made. In 1966, pectins and alcohol-insoluble solids were also determined. Objective determinations were made by previously described procedures (Bessey and King, 1933; Decker *et al.*, 1957, Gardner Laboratories, 1955; Roe *et al.*, 1948; Simandle *et al.*, 1966).

Sensory Evaluation. Panel evaluations were carried out by scalar scoring. Four whole berries chosen at random from each subplot of each treatment were served, one at a time, according to a randomized design (Cochran and Cox, 1957), to each of four judges who had been trained in judging fruits.

Residue Determinations. Pesticide residues were determined by a commercial laboratory. Chlordan was determined with a gas chromatograph equipped with an electron capture detector (Food and Drug Administration, 1963). Captan was determined by the AOAC procedure (Association of Official Analytical Chemists, 1965). Ferbam was determined by the procedure of Cullen (1964); the residue is decomposed and the evolved carbon disulfide reacts to form *N,N*-bis(2-hydroxyethyl) dithiocarbamate, which is determined colorimetrically. Demeton was estimated by the procedure of Kovacs (1964), in which the pesticide is isolated by thin-layer chromatography and the color developed by spraying with tetrabromophenolphthalein, silver nitrate, and citric acid.

RESULTS

Strawberries treated with chlordan or demeton were lower in malic acid than control strawberries (Table I). Although the differences in some cases were statistically significant, they were not very large. None of the other compositional or quality factors evaluated appeared to be affected by the pesticides used. After frozen storage, there was little difference in the quality of the control and the pesticide-treated strawberries.

Effects of captan and ferbam on strawberries are shown in Tables II and III. The fungicides used appeared to have little effect on composition or quality.

Pesticide Residues. Both the insecticide-treated strawberries grown in 1965 and the fungicide-treated strawberries grown in 1966 were submitted for analysis in July 1966. Samples of the 1965 strawberries were frozen and stored at 0°F. for approximately a year before pesticide residue analysis.

No measurable amounts of captan or ferbam were found on any of the samples tested. Traces of demeton were found on only two of the demeton-treated samples (Table IV). Some chlordan was found in all samples of both the control and the chlordan-treated samples in 1965. One control sample and three samples of chlordan-treated Earlidawn fruit contained more than 0.3 p.p.m. of chlordan.

In 1965, precise instructions for chlordan application were given. It seems likely, therefore, that chlordan present in the soil before 1965 was responsible for the high residues found on some strawberry samples. Because of the high mean values for chlordan in the control samples, 0.15 p.p.m. as compared to 0.23 p.p.m. for the treated samples, it was not possible to establish definitely whether or not chlordan affected the quality or compositional fac-

Table IV. Pesticide Residues on Strawberries^a

Variety	Chlordan, P.P.M.		Demeton, P.P.M.
	Control	Chlordan- treated	Demeton- treated
Earlidawn	0.36	0.48	0.05
	0.19	0.51	0.04
	0.18	0.41	0.00
	0.06	0.05	0.00
Armcore	0.06	0.08	0.00
	0.07	0.03	0.00
	0.10	0.04	0.00

^a Values are means of two replications on each of two samples.

tors evaluated. However, the residue results indicate that care should be exercised in the use of this insecticide in the growing of strawberries.

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