

Among the Hill Farm samples the flavor scores, even when significantly low, indicate only slight off-flavor and show no regular correlation with the dosage of insecticide to which soil was exposed or consistency among samples from replicate plots. In the samples from the Turner Farm only barely perceptible off-flavors were noted; there were no significant differences among these flavor scores. The sample from the plot treated with activated carbon did not differ significantly from the others. The general means of all flavor scores for each treatment also show no regular correlation with the quantities of insecticide to which soils were exposed.

Conclusions

In general, the results provide no evidence that the benzene hexachloride used on cotton accumulated appreciably in the soils or caused any flavor defects or accumulation in peanuts grown on the plots the following year. Because of its high gamma content, 36%, the heaviest dosage of 5.1 pounds of the gamma isomer per acre deposited only 14.0 pounds of total isomers per acre.

In tests on samples grown at Holland, Va., in 1951 (4), benzene hexachloride averaging 0.60 p.p.m. was found and off-flavors were observed when 5.1 pounds of the gamma isomer per acre was used; however, the total dosage of benzene hexachloride isomers was 41.1 pounds per acre.

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PESTICIDES AND FLAVOR

Flavor of Peanut Butter as Affected by Aldrin, Chlordan, Dieldrin, Heptachlor, and Toxaphene Used as Insecticides in Growing Peanuts

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FLAVOR DAMAGE TO SOME FOODS from use of benzene hexachloride as an insecticide in growing the crops has emphasized the importance of determining the effect of new insecticides on flavor of food before they are recommended for specific application.

While soil applications of comparatively low dosages of either technical benzene hexachloride or lindane give excellent control of southern corn rootworm on peanuts, previous studies made in this laboratory (7) have shown that peanuts grown in soils treated with either of these insecticides develop characteristic off-flavors and that these off-flavors may be present in peanut butter or carried over into potatoes french-fried in the peanut oil (made in the pilot plant of the Planters Nut and Chocolate Co., Suffolk, Va.). Other

investigators have reported similar results with peanuts and peanut butter (2).

In limited studies on peanut butter (7) from peanuts grown with aldrin, dieldrin, and toxaphene, insecticides which also give very effective control of the southern corn rootworm on peanuts, it appeared that, in the formulations and dosages used, these insecticides did not affect the flavor of the product. Because the previous tests were limited, further studies were carried out in 1951 and 1952 to evaluate the flavor of peanuts grown in soils treated with these insecticides and with heptachlor and chlordan. Tests with aldrin, toxaphene, and heptachlor included variations in dosage rates, insecticide formulations, and methods of application with different kinds of farm equipment.

Peanuts used in these studies were

grown at the Tidewater Field Station (Holland, Va.) of the Virginia Agricultural Experiment Station under carefully controlled conditions or at outlying farms in Nansemond County and other counties in the Virginia peanut-growing area. In several instances, the same insecticide treatment was used at two of the locations. The peanuts were grown in heavy or moderately heavy soils, with the exception of samples No. 7 and 20, Table I, which were grown in light, sandy soil.

The peanuts for the 1951 study (Table I) were of Virginia Jumbo variety, except for samples 6, 11, and 19, which were Virginia Runner variety. Eighteen samples were from treated fields and three were check samples from untreated fields. The treated samples included nine grown with aldrin, six

Palatability tests were made on peanut butter prepared from peanuts grown in Virginia in soil treated with aldrin, dieldrin, chlordan, heptachlor, or toxaphene for the control of the southern corn rootworm. The insecticides were used in various formulations and dosages and applied to the soil in several ways. No definite off-flavors that could be attributed to the insecticide treatments tested were observed in the peanut butter samples. On the basis of these results, together with the results of field tests of their effectiveness as insecticides and their relative cost, the department in 1953 recommended soil applications of aldrin or heptachlor at the rate of 2 pounds per acre or toxaphene at 25 pounds per acre, immediately prior to the first cultivation, for control of the southern corn rootworm in peanuts.

with toxaphene, and one each with heptachlor, dieldrin, and chlordan; dosages and methods of application of the insecticides are given in the table.

From the 1952 harvest 13 samples were of Virginia Jumbo variety and 7 were Adkins Runner variety (Table II). Eighteen samples were from treated fields, the other 2 were from untreated fields to provide one check for each variety. The treated samples included 6 grown in soils treated with heptachlor, 5 with toxaphene, 6 with aldrin, and 1 with dieldrin; insecticide dosages and formulations varied as shown in the table. Some of the insecticides were in the new granular formulations which had not been included in previous years' studies.

Each sample of peanuts was shelled, cleaned, roasted, and processed into peanut butter in a laboratory of the Horticultural Crops Research Branch. All samples of peanut butter were stored at 38° F. until needed for scoring but were brought to room temperature (about 75° F.) before serving. One-half teaspoon samples were served on coded small white china plates.

The judging panel consisted of 5 persons experienced in rating the flavor of peanut butter. The panel members were selected and trained on peanut butter prepared from specially grown control samples of peanuts, commercial peanut butter, and samples from peanuts grown with benzene hexachloride mixed with various concentrations of natural flavored peanut butter as described in a previous publication (3). Scoring was on a 10-point scale with 10, indicating no off-flavor; 8, barely perceptible off-flavor; 6, perceptible off-flavor; 4, slightly strong off-flavor; and 2, strong off-flavor.

In tests on the 1951 samples the experimental design used in the palatability scoring was a balanced incomplete block. Each of the 5 panel members scored 3 samples at every judging session. There were 14 sessions and each person rated all 21 samples once in the first 7 sessions

and again in the last 7 sessions to make 2 complete replications or 10 ratings per sample. The design used for scoring the 1952 samples consisted of three repetitions of a 4 × 5 triple rectangular lattice. All 20 samples were rated by 5 persons who rated 4 samples each at every judging session. The experi-

mental design provided for scoring of each sample once by one panel member during every judging session. As there were 9 sessions during the 1952 palatability study, each sample was rated 9 times. Both designs permit comparisons between any pairs of samples or between any groups. The difference in designs

Table I. Mean Flavor Scores for Peanut Butter from Peanuts Grown in Treated Soils

(Holland, Va., 1951)

Sample No.	Insecticide and Formulation ^a	Toxicant, lb./Acre	Method of Application	Mean Flavor Score ^b
1	Aldrin, 10% dust	4.0	Power duster	8.8
2	Aldrin, in pyrophyllite	4.0	Hand broadcast	8.8
3	Aldrin, in 0-10-20 fertilizer	3.0	16-inch band	7.8
4	Aldrin, in 0-10-20 fertilizer	3.0	16-inch band	8.5
5	Aldrin, in 0-14-14 fertilizer	2.0	36-inch area	8.6
6	Aldrin, in 0-10-20 fertilizer ^c	2.0	16-inch band	5.2 ^d
7	Aldrin, in 0-10-20 fertilizer ^e	2.0	16-inch band	9.2
8	Aldrin, 10% dust	2.0	Power duster	9.1
9	Aldrin, 2.5% dust ^f	2.0	Power duster	8.4
10	Toxaphene, in 0-10-20 fertilizer	25.0	16-inch band	8.7
11	Toxaphene, in 0-10-20 fertilizer ^c	25.0	16-inch band	9.2
12	Toxaphene, in 0-10-20 fertilizer	25.0	36-inch area	8.4
13	Toxaphene, in pyrophyllite	25.0	Hand broadcast	9.6
14	Toxaphene, in 0-10-20 fertilizer	15.0	16-inch band	8.9
15	Toxaphene, 10% dust ^f	8.0	Power duster	8.7
16	Heptachlor, in pyrophyllite	4.0	Hand broadcast	9.6
17	Dieldrin, in pyrophyllite	2.0	Hand broadcast	7.8
18	Chlordan, in pyrophyllite	10.0	Hand broadcast	7.9
19	Untreated, check sample for Nos. 6 and 11 ^c	0.0	...	9.2
20	Untreated, check sample for No. 7 ^e	0.0	...	8.3
21	Untreated, check sample, general	0.0	...	9.7

^a Insecticide applied immediately prior to first cultivation.

^b Mean of 9 ratings on 10-point scale. 10, no off-flavor; 8, barely perceptible off-flavor; 6, perceptible off-flavor; 4, slightly strong off-flavor; 2, strong off-flavor.

^c Virginia Runner variety (other samples were Virginia Jumbo variety).

^d Significantly lower than other samples at 5% level.

^e Grown on light, sandy soil.

^f Four applications to foliage; last 3 in sulfur.

Table II. Mean Flavor Scores for Peanut Butter from Peanuts Grown in Treated Soils

(Holland, Va., 1952)

Sample No.	Insecticide and Formulation ^a	Toxicant, Lb./Acre	Method of Application	Mean Flavor Score ^b
1	Aldrin, in 0-10-20 fertilizer	2.1	T.F.A. ^c	9.6
2	Aldrin, 5%-clay granular	2.0	Power duster	9.3
3	Aldrin, 2%-clay granular	2.0	Hand broadcast	9.7
4	Aldrin, 5% dust	2.0	P.T.O. duster ^d	9.8
5	Aldrin, 10% dust	2.0	P.T.O. duster	8.1
6	Aldrin, 2%-tobacco granular	1.9	T.F.A.	9.4
7	Toxaphene, 25%-clay granular	38.0	Power duster	8.6
8	Toxaphene, 20% dust	28.4	Traction duster	9.4
9	Toxaphene, in 0-10-20 fertilizer	22.0	T.F.A.	9.3
10	Toxaphene, in 0-10-20 fertilizer	20.0	T.F.A.	9.6
11	Toxaphene, 25%-clay granular	20.0	T.F.A.	9.4
12	Heptachlor, tobacco granular	2.3	T.F.A.	9.4
13	Heptachlor, in 0-10-20 fertilizer	2.0	T.F.A.	8.7
14	Heptachlor, tobacco granular	2.0	T.F.A.	9.2
15	Heptachlor, 5% dust	2.0	Power duster	9.3
16	Heptachlor, in 0-10-20 fertilizer	1.9	T.F.A.	9.6
17	Heptachlor, in 0-10-20 fertilizer	1.9	T.F.A.	9.7
18	Dieldrin, in 0-10-20 fertilizer	2.1	T.F.A.	9.0
19	Untreated, check sample ^e	0.0	...	9.9
20	Untreated, check sample ^f	0.0	...	9.6

^a Insecticide applied immediately prior to first cultivation.

^b Mean of 9 ratings on 10-point scale. 10, no off-flavor; 8, barely perceptible off-flavor; 6, perceptible off-flavor; 4, slightly strong off-flavor; 2, strong off-flavor.

^c Tractor fertilizer side dressing attachment.

^d Power take-off duster.

^e Check for Virginia Jumbo samples 1, 2, 3, 4, 7, 8, 10, 13, 14, 15, 16, 18.

^f Check for Adkins Runner samples 5, 6, 9, 11, 12, 17.

was required to accommodate the number of samples under investigation in each series.

Results

The field tests showed that applications to the soil of aldrin or heptachlor at the rate of 2 pounds per acre or toxaphene at 25 pounds per acre, immediately prior to the first cultivation, controlled the southern corn rootworm in peanuts. Effective control resulted from these dosages when the insecticides were applied in fertilizer, pyrophyllite, Attaclay (Attapulgis Clay Co., Philadelphia, Pa.), or tobacco stems (tobacco granular) (Tobacco By-Products and Chemical Corp., Richmond, Va.). While dieldrin and chlordan also controlled the southern corn rootworm in peanuts, they appear to have no advantages over aldrin, heptachlor, or toxaphene.

Results of palatability studies showed that differences between mean flavor scores for the samples grown in soils treated with aldrin, toxaphene, heptachlor, dieldrin, or chlordan in the dosages and forms used and scores for control samples from untreated plots were not statistically significant except in one instance with aldrin-treated peanuts

which scored 5.2. With this one exception the mean flavor scores for all samples of peanut butter from peanuts grown in aldrin-treated soil ranged from 7.8 to 9.8 (Tables I and II). Since several high-scoring samples were from peanuts having either the same treatment or a heavier dosage of aldrin than the sample which scored 5.2, it seems probable that some factor other than the insecticide was responsible for the low score. In all other cases the scores indicated that any off-flavors noted were considered by the panel to be barely perceptible and were unrelated to the dosages used in this study.

Mean flavor scores for samples from peanuts grown in toxaphene-treated soil ranged from 8.4 to 9.6; the differences for samples treated with the various forms and dosages of the insecticide were not statistically significant. Again, any off-flavor observed was considered only barely perceptible by most panel members.

Peanut butter from peanuts grown in heptachlor-treated soils had mean flavor scores ranging from 8.7 to 9.7, but differences in the scores for the samples exposed to the various forms and different dosages of heptachlor were not significant. Most of the panel members found

no off-flavor in these samples, and the persons reporting off-flavor generally rated it as barely perceptible in intensity.

Of the two samples from dieldrin-treated soil, that grown in 1951 had a mean flavor score of 7.8, the 1952 sample, 9.0. Since a score of 7.8 represents barely perceptible off-flavor, and 9 even less off-flavor, these mean scores indicate that the panel found very little off-flavor in the peanut butter made from samples grown in dieldrin-treated soils.

The one sample on which chlordan was used scored 7.9 on flavor, which was not significantly different from the score of 9.7 for the general check sample.

Comments on the kind of off-flavors observed in the various samples were similar, whether the samples were from treated or untreated soils. No significant relationships were observed between flavor of peanut butter and variety of peanuts from which it was made, location of the field and type of soil where they were grown, and method of application of the insecticide.

Results of these palatability studies and of the field tests mentioned above were the basis for the department recommendation in 1953 that soil applications of aldrin or heptachlor at the rate of 2 pounds per acre or toxaphene at 25 pounds per acre, applied immediately prior to the first cultivation, be used for control of the southern corn rootworm in peanuts.

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