Table I. Ingested C^{14} Found in Crude Fat Fraction (Chloroform-Soluble) and Distribution of C^{14} in Hydrolytic Products of Crude Fat

	Radioactive Anhydrosorbitol Monostearate, %									R.A. Glucose (Controls), %	
Rat No.	1	2	3	4	5	6	7	8	9	10–11	12–13
Crude fat[a]	0.35	0.31	0.35	0.34	0.43	0.41	0.49	0.35	0.49	3.59	3.01
Fatty acids	0.23	0.21	0.25	0.20	0.19	0.29	0.32	0.15	0.25	1.25	1.38
Glycerol		0.03			0.07			0.01		0.93	0.95
Residue		0.04			0.09			0.07		0.54	0.39

[a] Crude fat from each animal was saponified separately for isolation of fatty acids except in radioactive glucose control animals, in which crude fats for 10 and 11 and for 12 and 13 were combined. In isolation of glycerol and residue fraction, corresponding fractions for animals 1, 2, and 3, animals 4, 5, and 6, and animals 7, 8, and 9 were combined.

of the glycerol after making the appropriate correction for the carbon introduced by the benzoate. The carbon-14 content of the nonsublimable unidentified residue, which would contain any anhydrosorbitol polyols if present, was determined. The results are shown in Table I.

Discussion

In confirmation of previous work it was found that a small portion of the carbon-14 fed as anhydrosorbitol esters appeared in the chloroform-soluble crude fat, with the activity distributed in the fatty acids, glycerol, and the nonsublimable residue. The unidentified residue which could be presumed to be the anhydrosorbitol polyols was of the same order of magnitude following the 28-day feeding period as was observed in the previous single dose experiments; this indicated the absence of accumulation. That this unidentified residue is probably not the polyol fraction of the fed ester is suggested by the finding that a corresponding fraction was obtained in even greater amounts from the crude fat extracted from the carcasses of rats fed labeled glucose without labeled anhydrosorbitol esters. The higher percentage of carbon-14 in the crude fat and its fractionated components of the labeled glucose–fed rats as compared with the labeled ester–fed rats is to be expected in view of the known metabolic fate of glucose and the previously demonstrated rapid excretion of the anhydrosorbitol polyols (*2*).

Literature Cited

(1) Pratt, C. D., *Food Technol.*, **6**, 425–30 (1952).
(2) Wick, A. N., and Joseph, L., *Food Research*, **18**, 79–84 (1953).

Received for review April 20, 1953. Accepted May 6, 1953.

FLAVOR AND SOIL TREATMENT

Flavor of Selected Vegetables Grown in Soil Treated With Isomers of Benzene Hexachloride

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Studies were made to determine the effect on flavor of tomatoes, lima beans, potatoes, radishes, and carrots from use of purified gamma, alpha, beta, and delta isomers of benzene hexachloride, a mixture of these isomers, commercial gamma isomer, and lindane as insecticides in growing the vegetables. The results indicate that flavor may be affected by certain formulations of benzene hexachloride; the effect on flavor varies with the formulation, the dosage rate, and the type of vegetable grown.

BENZENE HEXACHLORIDE USED IN THE soil as an insecticide has been found to impart off-flavors to some vegetables. Susceptibility to such contamination of flavor appears to vary with the type of vegetable, the formulation of benzene hexachloride (BHC), the amount used, and the time and method of application (*2–7*).

Studies were started at Beltsville, Md., during the summer of 1948 to ascertain the role played by each of the four major isomers in technical benzene hexachloride when applied to the soil in causing the objectionable flavor or odor of vegetables. As there were indications that some of the isomers caused more off-flavors than others (*6*), further studies were planned.

Reported here are studies on tomatoes, lima beans, and potatoes used during 1949 in tests with the chemically pure gamma, alpha, beta, and delta isomers of benzene hexachloride, and on radishes and carrots used in 1950 in tests with lindane (99.9% gamma isomer). Experiments on potatoes grown in 1950 with lindane were reported by Kirkpatrick *et al.* (*3*). [The name lindane has been established by the U. S. Interdepartmental Committee on Pest Control (*9*) as the common name for the gamma isomer of benzene hexachloride of a purity of not less than 99%.]

The vegetables were grown by the Bureau of Entomology and Plant Quarantine and the quality studies were carried out by the Bureau of Human Nutrition and Home Economics.

General Procedure for Growing Crops

The crops were grown in 3-gallon crocks to prevent any possible contamination by soil movement that might occur if grown in the open fields. The crocks were glazed inside and out. They were 9.25 inches in diameter and 11.25 inches high, inside measurements, and when filled with soil to within 2 inches of the top rim as used, had a capacity of 0.359

cubic foot. The crocks were provided with 1.5-inch drainage hole in the bottom. A piece of copper screening was placed over the drainage hole, and covered with a quart of washed gravel to ensure proper drainage.

In the experiments on tomatoes, lima beans, and potatoes, local Sassafras sandy loam soil was used with the isomers of benzene hexachloride. Fertilizer at the rate of 1000 pounds per acre was used in both the 1949 and 1950 tests. The soil mixture for each crock was prepared separately. The required quantity of soil and fertilizer to fill the crock to within 2 inches of the top rim was first mixed in a shallow metal trough, then the required quantity of isomer was sprinkled over the surface and the mixture was thoroughly worked again to ensure an even distribution of both fertilizer and isomer throughout the soil mass. In the case of potatoes, however, one half of the total number of crocks was prepared as above and one half was handled as follows: The fertilizer and isomer were mixed and then placed in a circular band around the seed piece, the latter being placed at a depth of 2 inches below the top level of soil. This was done to simulate application by the band method as sometimes used in the field.

After the crops were planted, the crocks were sunk in the field to within 3 to 4 inches of the top rim. A shovelful of $^3/_4$-inch washed gravel was placed under each crock to ensure good drainage. Six replicated crocks were used for each treatment and for the untreated check. They were placed 5 feet apart in check rows and the various treatments were arranged at random.

In the 1950 experiments with lindane on radishes and carrots, some modification in procedure was made, in that composted soil (Chester type) was employed instead of the field run of Sassafras loam. Before the lindane powder was added to this soil, it was extended with finely screened soil to increase the bulk and ensure better distribution. Also, instead of weighing each lot of lindane separately for each crock, a sufficient quantity of soil for all crocks needed at one dosage level was prepared by thoroughly mixing with the insecticide. Then the required volume was placed in each of eight replicate crocks for each treatment.

Seedling Marglobe tomato plants were transplanted to the crocks on May 13, 1949, and the first ripe fruits were picked July 19. Fordhook lima beans were planted on June 13, 1949. Two harvestings were made, the first on August 9 and the second on September 12. Seed pieces of Irish Cobbler potatoes were planted on April 25, 1949, the tubers were harvested on July 18, and taste testing was done on August 17 and 18. In the interim the tubers were stored in paper bags at room temperature. All tubers were firm and no spoilage occurred. Nantes carrots and Globe radishes were planted on April 30, 1950. Radishes were harvested on May 29 and 31 and carrots on August 3 and 4.

Growth was fairly normal, although some difficulty is experienced when raising crops in containers because of the restricted growing area. No injury to the growth which could be attributed to any of the isomers was observed.

Insecticidal Treatments

The seven treatments listed in Table I were tested on tomatoes, lima beans, and potatoes in 1949. The dosages given in the table are in the approximate ratio that the isomers are found in technical benzene hexachloride. Treatments 1, 5, and 6 are at dosages about four times that required to give good control of wireworm. The dosage in treatment 5 is about twice that reported to have been widely used in New Jersey in 1947, when off-flavors in potatoes were reported by consumers.

The insecticide materials for the study were furnished by the California Spray-Chemical Corp. The isomers were prepared by recrystallization from organic solvents and checked for purity by melting point determination and by infrared spectrometer analysis. Each isomer was formulated into a 25% wettable powder through the same grinding equipment and using the same wetting agent and diluent. Every possible precaution was taken to prevent contamination. The wetting agent, an alkyl aryl polyethylene glycol ether (Igepal CA-300), was added as 1% of the total weight of isomer and inert material. The inert material used, Attapulgus clay, had a pH of about 7 and constituted 74% of each mixture. The four pure isomers also were mixed in the proportion found in technical benzene hexachloride from which they were derived, and formulated into a similar 25% wettable product. A commercial product containing 97.7% of gamma-benzene hexachloride was also included in the experiment.

In 1950 the following dosages of lindane were used in growing radishes and carrots: 0.25, 1, and 4 pounds per acre. Check samples grown on untreated plots were included in the study.

Selection of Palatability Panel

People differ greatly in their ability to detect flavors in food (*1*). As it was desired that each judge be able to distinguish even small amounts of benzene hexachloride which might be present, the threshold sensitivity to benzene hexachloride in water solution was determined for each prospective panel member. Members of the staffs of Bureau of Human Nutrition and Home Economics, the Bureau of Entomology and Plant Quarantine, and the Bureau of Plant Industry, Soils, and Agricultural Engineering, most of whom had previous experience in detecting off-flavor in foods contaminated with benzene hexachloride, were tested to determine their thresholds for detecting this substance.

The preparation used for making up the solutions for the threshold test was the commercial gamma-benzene hexachloride containing 97.7% gamma isomer, 1.8% alpha isomer, 0.1% delta isomer, and 0.4% epsilon isomer. Gamma isomer content was reduced to 25% by mixing with Attapulgus clay and 1% Igepal CA-300. Dilutions of this preparation were made up with distilled water so that they contained 2.5, 1.25, 0.25, 0.05, and 0.025 p.p.m. of gamma isomer.

Five paired samples, each pair consisting of one dilution of benzene hexachloride and a sample of distilled water,

Table I. Treatments and Dosages of Isomers of Benzene Hexachloride Used in Growing Tomatoes, Lima Beans, and Potatoes

No.	Treatment	Dosage[a] Lb./acre	Dosage[a] Mg./crock
	Isomer of benzene hexachloride		
1	Gamma (99.98% purity)	2[b]	13.5
2	Alpha (99.80% purity)	12	80.8
3	Beta (99.96% purity)	2	13.5
4	Delta (99.93% purity)	1	6.7
5	Mixture of gamma, alpha, beta, delta isomers[c]	17[b]	114.5
6	Commercial gamma (97.7% purity)	2[b]	13.5
7	Untreated check	0	0

[a] Dosage of isomer used, excluding inert material and wetting agent. Volume of soil in each crock, 0.359 cu. foot.
[b] Treatments 1, 5, and 6 based on 4 times that required for wireworm control.
[c] Analysis of mixed isomers, %

Gamma	13
Alpha	65
Beta	10
Delta	9
Inert	3
Total	100

were presented in small beakers in random order to the prospective panel members. Each person was asked to identify the sample with an off-flavor or to indicate that there was no difference in the two samples. Two repetitions of the test were made.

Of the 25 persons participating in the threshold test [including responses of persons tested in selection of a panel for judging potatoes grown with lindane (*3*)], 1 detected commercial gamma-benzene hexachloride accurately in duplicate paired samples of water solutions at concentrations of 0.05 p.p.m., 3 in concentrations of 0.25 p.p.m., 12 in concentrations of 1.25 p.p.m., and 4 in concentrations of 2.5 p.p.m. (Table II). The remaining five persons were unable to duplicate their judgments and it was therefore assumed that their thresholds of taste perception for benzene hexachloride were higher than 2.5 p.p.m. On the basis of these findings, the persons tested were classified into five groups with low to high thresholds as shown in Table II.

Table II. Prospective Panel Members Classified According to Taste Sensitivity to Benzene Hexachloride

Group	No. of Persons	BHC Concn.[a] Detected in Solution in Duplicate Samples, P.P.M.
I	1	0.05
II	3	0.25
III	12	1.25
IV	4	2.5
V	5	>2.5

[a] Commercial gamma-benzene hexachloride containing 97.7% gamma isomer, 1.8% alpha isomer, 0.1% delta isomer, and 0.4% epsilon isomer.

Further evidence of the performance and reliability of the prospective panel members was obtained in a test on duplicate sets of paired samples of pure isomers of benzene hexachloride in water solutions (Table III). Each of the four isomers of benzene hexachloride—gamma, alpha, beta, and delta—was dissolved in distilled water in dilutions of 0.25 p.p.m. Each isomer solution was paired with a sample of distilled water and presented to the prospective panel members for identification of the sample containing benzene hexachloride.

The five persons who were unable to duplicate their judgments on the threshold test, classified as group V in Table II, also were unable to duplicate their flavor ratings on a second set of identical samples of the isomers, except for one person who duplicated ratings on the alpha isomer. On the basis of these tests, the persons in group V were not used on the vegetable testing panels. All the other persons tested in groups I, II, III, and IV were able to duplicate their flavor ratings on two or more of the isomers.

Table III. Number of Persons Detecting Off-flavor

(In solutions of isomers of benzene hexachloride at 0.25 p.p.m. concentration paired with samples of distilled water)

Group	No. in Group	Isomer of Benzene Hexachloride in Solution: Gamma	Alpha	Beta	Delta
		No. detecting off-flavor in duplicate samples of isomers			
I	1	..	1	1	1
II	3	..	0	3	3
III	12	0	1	12	11
IV	4	0	0	4	2
V	5	0	1	0	0
Total	25	0	3	20	17
		No. detecting off-flavor in single samples of isomers			
I	1	0	1	1	1
II	3	0	0	3	3
III	12	4	4	12	11
IV	4	3	2	4	4
V	5	2	2	4	2
Total	25	9	9	24	21

A definite difference in off-flavor present was found in the solutions of the four different isomers of benzene hexachloride as determined by the number of persons who could detect an off-flavor. Solutions of beta and delta isomers appeared to have the most off-flavor; these solutions were correctly identified by the majority of panel members (Table III) in both single and duplicate pairs of samples. Off-flavors were noticed by nine panel members in single samples of gamma and alpha isomers paired with water. Only three persons were able to duplicate their flavor ratings on the alpha isomer, and no one was able to duplicate his rating on the gamma isomer. Therefore, it appears that the flavor imparted by gamma and alpha isomers approximates the threshold sensitivities of the panel members, yet is not strong enough to be noticed consistently.

The panels used to rate the vegetables were selected on the basis of threshold tests and on the availability of the various persons at the time of the palatability studies. The size of the panel and its personnel varied slightly for the different vegetables.

Procedures for Palatability Tests

Tomatoes Experimental tomatoes from treated and untreated soil and untreated garden tomatoes were held in the refrigerator after harvest until 1 hour before serving time, when they were removed to a room temperature of approximately 75° F. (24° C.). The six replicates for each treatment were pooled. Each tomato was washed in distilled water, and cut in half from blossom to stem end, then each half was cut in fourths to make eight wedges. Each wedge was placed on a small white coded plate and samples were served to the palatability panel at 2-minute intervals. Ten to 12 samples were tested at one session. Untreated garden tomatoes were included both as a labeled reference standard and as a coded control. The judges were asked to indicate on the score sheet the presence or absence of off-flavor and to name any off-flavor if possible. At least 10 repetitions of each treatment were judged during the experiment which extended over several weeks.

Lima Beans The lima beans were rated the day they were harvested; they were held at room temperature not more than 2 hours until used. The six replicates of each treatment of lima beans were pooled to make a large enough sample for cooking. They were shelled, washed in distilled water, and cooked 30 minutes in boiling distilled water, using 1 gram of water per gram of vegetable. Duplicate samples from each cooked lot were served to the judges in random order on coded white plates. The beans were harvested at two different times; thus four samples of each treatment were rated by each judge. Untreated garden-fresh lima beans were included as control samples. The rating system used for tomatoes was employed.

Potatoes Potatoes were harvested and stored at room temperature for 1 month before cooking and palatability tests were made. Because the tubers were small, three replicates for each treatment were combined to make a large enough sample for cooking. Each cooking sample of potatoes selected for uniformity of size was washed and unpared tubers were covered with 800 ml. of boiling distilled water and cooked in a covered pan. A thermocouple was threaded into one tuber of each sample with the thermocouple junction in the center of the tuber to measure internal temperature as a control for doneness. Temperatures were recorded on a potentiometer and potatoes were cooked to an

Table IV. Off-flavor in Tomatoes and Lima Beans

(Grown in untreated soil and in soil treated with isomers of benzene hexachloride)

Treatment	Tomatoes		Lima Beans	
	No. of samples tested[a]	% of samples in which off-flavor detected	No. of samples tested[a]	% of samples in which off-flavor detected
Gamma isomer	87	20	28	18
Alpha isomer	88	26	28	11
Beta isomer	83	25	28	18
Delta isomer	101	24	28	50
Mixture of isomers	73	41	21	29
Commercial gamma isomer	78	24	28	32
Untreated check	68	24	28	7
Garden control	122	21	7	14
Grocery control	70	19	..	..

[a] Samples × judges.

internal temperature of 205° F. (96° C.). Boiled potatoes were peeled and then mashed to obtain a blended sample for serving to the judges. Part of the mashed sample was refrigerated and later fried as patties. A panel of eight judges scored the mashed samples and five scored the fried samples for flavor and odor. A 3-point numerical scale was used, with 3 representing the highest possible score and 1 the poorest. Flavor scores were studied by analysis of variance.

Radishes The radishes were harvested and rated for palatability on the same day. They were washed well in running tap water, trimmed, and cut in halves or quarters, depending on size. All eight replicates were pooled and random samples were taken from each lot and coded for serving to the taste panel.

The panel consisted of five persons who made quality evaluations on four replicate samples for each treatment by scoring flavor and general acceptability on 5-point rating scales. In addition, paired comparison tests for flavor were made of untreated controls paired with samples grown using 1 or 4 pounds of lindane per acre. Only four samples were scored or four pairs of samples were rated by paired comparison in any one tasting session.

Significance of differences in the numerical scoring and in the paired comparison methods was determined by analysis of variance and the Chi square test, respectively.

Carrots Palatability ratings on carrots were made by a panel of five persons who scored flavor and general acceptability on 5-point rating scales. Each lot of carrots was divided into three equal portions to make three replicates. Carrots from all four treatments were included in each tasting session, so that direct comparison was possible. All palatability comparisons were made against the untreated control. Samples were randomized and coded for each palatability test.

The carrots were served in lengthwise strips uncooked and after cooking for 20 minutes in distilled water, using equal weights of water and carrots in cooking.

Statistical significance of the difference in mean scores on treated and untreated samples was determined by analysis of variance and by Tukey's method of analysis (*8*).

Results

Tomatoes Grown In Treated Soil The results of the flavor tests (Table IV) show that a greater percentage, 41% of off-flavors, was detected in tomatoes which were grown in soil treated with a mixture of the isomers at a dosage rate of 17 pounds per acre than in those from any of the other treatments in which 20 to 26% were detected. This was the largest dosage of any used; the effects of the various isomers may have been additive in the mixture. The off-flavors in tomatoes treated with the mixture of isomers were variously described as earthy, musty, astringent, metallic, oily, pungent, bitter, flat, stale, spoiled, sweet, and typical benzene hexachloride.

It was apparent that factors other than the insecticide affected the flavor of the tomatoes as shown by the comparable percentage of off-flavors detected in the untreated samples and in samples treated with the pure gamma, alpha, and beta isomers, and the commercial gamma. According to the judges' comments, the flavor of tomatoes in any one lot varied considerably.

Lima Beans Grown In Treated Soil Palatability data on lima beans also are given in Table IV. A greater percentage detection of off-flavors was found in the sample grown in soil treated with the delta isomer of benzene hexachloride at a dosage rate of 1 pound per acre than in those from any of the other treatments; slightly lower percentages for detection of off-flavors were noted for the samples from the treatments with the mixture of isomers at 17 pounds per acre and with the commercial gamma-benzene hexachloride at 2 pounds per acre. Treatment with these amounts of commercial gamma or the mixture of isomers resulted in greater percentage of off-flavor in lima beans than did treatment with pure gamma or beta isomers at 2 pounds per acre or alpha isomer at 12 pounds per acre. The off-flavors found in the samples from treated soil were described as bitter, musty, earthy, fishy, stings tip or back of tongue, and typical benzene hexachloride. Off-flavors were detected in only a few instances in the untreated check samples and the garden controls.

Potatoes Grown In Treated Soil The analysis of variance showed no differential response to the two methods used in applying the isomers to the soil. The significance of results under the two cooking methods was identical and each method produced means in the same sequence. Accordingly the results are presented on the combined mean basis.

Lowest score for flavor of cooked potatoes (score 1.2) was obtained from the use of the mixture of isomers applied at a dosage rate of 17 pounds per acre (Table V). Applications of commercial gamma at dosages of 2 pounds per acre, alpha isomer at 12 pounds per acre, and gamma isomer at 2 pounds per acre gave scores of 1.5, 1.6, and 1.7, respectively.

Table V. Mean Scores for Flavor of Potatoes

(Including samples in which BHC was detected in potatoes grown in soil treated with various isomers of benzene hexochloride)

Treatment	No. of Samples Tested[a]	% Samples in Which BHC Detected	Mean Scores for Flavor[b]
Mixture of isomers	26	100	1.2[c]
Commercial gamma isomer	26	81	1.5[c]
Alpha isomer	21	81	1.6[c]
Gamma isomer	26	62	1.7[c]
Delta isomer	26	58	2.2
Beta isomer	26	23	2.3
Untreated control	21	14	2.4

[a] Samples × judges.

[b] Score of 3 represents natural desirable flavor; 2, slightly undesirable flavor, moderate off-flavor; 1, undesirable flavor, strong off-flavor.

[c] Significance at 5% level.

Table VI. Mean Palatability Scores for Radishes and Carrots Grown in Soil Treated with Lindane

Vegetable	Lindane Treatment, Lb.	Off-flavor[a]	Acceptability[a]
Radishes	Untreated	4.5	3.6
	0.25	4.4	3.4
	1	4.5[b]	3.6[b]
	4	3.6	3.0
Carrots (raw)	Untreated	4.1	3.1
	0.25	3.9	3.1
	1	4.2	3.3
	4	3.9	3.1
Carrots (cooked)	Untreated	4.7	3.3
	0.25	4.6	3.1[b]
	1	4.1[b]	2.5
	4	3.4	2.3

[a] For radishes, mean of 4 replicates rated by 5 judges; for carrots, 3 replicates rated by 5 judges.
Rating scale for intensity of off-flavor: 5, none; 4, slight; 3, moderate; 2, moderately strong; 1, very strong. In acceptability a score of 5 is very good; 4, good; 3, fair; 2, poor; 1, very poor.
[b] Mean scores above the line are significantly different from those below the line.

Table VII. Detection of Off-flavor in Paired Comparison Tests on Radishes Grown in Soil Treated with Lindane

Pair of Samples	Total Tests on Paired Samples[a]	No. of Times Off-flavor Detected: Untreated samples	No. of Times Off-flavor Detected: Treated samples	No. of Times No Difference Detected in Paired Samples	Chi Square
Untreated and treated with 4 lb. lindane/acre	60	17	35	8	5.40[b]
Untreated and treated with 1 lb. lindane/acre	20	4	7	9	0.45

[a] Samples × judges.
[b] Significant at 5% level for d.f. = 1.

Scores from all four treatments were statistically different from the score 2.4 for the untreated control. The fact that flavor scores for potatoes grown in soil treated with alpha isomer closely parallel scores for potatoes grown in soil treated with the mixture of isomers is not surprising, as the alpha isomer makes up such a large proportion (65%) of the mixture (Table I). In addition, both the alpha isomer and the mixture of isomers were applied in very high dosages, 12 and 17 pounds per acre, respectively. Nonsignificant differences in flavor scores were obtained from the use of beta and delta isomers at dosages of 2 and 1 pounds per acre, respectively.

Table V also shows the percentage of samples in which benzene hexachloride was detected. Potatoes grown in soil treated with the mixture of isomers had a strong off-flavor that was detected by all judges and identified as benzene hexachloride in every case. Characteristic benzene hexachloride flavor again was detected and identified in 81% of the samples from treatments with pure alpha isomer and also from treatments with commercial gamma isomer. Of the four isomers used, the least number of reports of off-flavor were made by the judges on potatoes grown in soil treated with beta isomer. This sample compared favorably with the untreated controls, which rated higher than samples from the treatments.

Radishes Grown In Soil Treated With Lindane

The average scores for radishes grown in soil treated with various amounts of lindane are given in Table VI. All the radishes were small and unusually sharp flavored, which may account for the relatively poor acceptability ratings on all samples.

Significantly more off-flavor was noted in the radishes grown in soil treated with 4 pounds of lindane per acre than in those from soil treated with 0.25 or 1 pound of lindane per acre. The latter two treatments had no more off-flavor than the untreated control.

The results obtained by scoring were confirmed by a paired comparison test on off-flavor in radishes from treated and untreated soil taken from the same lots that were used for scoring. Results of the paired comparison test are given in Table VII. When radishes from soil receiving the 4-pound treatment were paired with untreated controls, 35 out of 60 ratings indicated the presence of an off-flavor in the radishes from treated soil, and 17 out of 60 in the untreated samples. The difference between these two lots proved to be statistically significant when tested by the Chi square method. The difference between the number of times off-flavor was detected in samples treated with 1 pound of lindane and in untreated samples was not significant.

Carrots Grown In Soil Treated With Lindane

Flavor and general acceptability of raw carrots were unaffected by treatment of the soil with lindane at dosage rates of 0.25, 1, or 4 pounds per acre (Table VI). However, significant effects on these palatability factors were noted when carrots were cooked before tasting.

By applying the statistical method proposed by Tukey to the mean scores for flavor of cooked carrots, those grown in soil treated with 4 pounds of lindane per acre were significantly different from the untreated carrots and those from soil treated with 0.25 and 1 pound of lindane per acre.

Mean scores for acceptability, which is an over-all rating based on color and texture as well as flavor, showed that carrots grown with 1 pound of lindane as well as those with 4 pounds of lindane were significantly poorer than the untreated check or carrots grown with 0.25 pound of lindane.

Acknowledgment

The authors wish to express their appreciation to Betsy L. Harris, Beatrice M. Mountjoy, M. Patricia Trimble, Eleanor L. Geissenhainer, and Linda C. Albright for valuable assistance in conducting the flavor investigations and to Elsie F. Dochterman and Albert B. Parks, Bureau of Human Nutrition and Home Economics, who performed the statistical analysis of the palatability data. Thanks are also due to L. B. Reed, Bureau of Entomology and Plant Quarantine, for valuable advice and assistance in the planning of these experiments.

Literature Cited

(1) Dawson, E. H., *et al.*, U. S. Dept. Agr., *Inform. Bull.* **34** (1952).
(2) Gould, W. A., Sleesman, J. P., Rings, R. W., Lynn, M., Frantz, F., Jr., and Brown, H. D., *Food Technol.*, **5,** 129–33 (1951).
(3) Kirkpatrick, M. E., Mountjoy, B. M., Albright, L. C., Poos, F. W., and Weigel, C. A., *Am. Potato J.*, **28,** 792–9 (1951).
(4) O'Kane, W. C., *J. Econ. Entomol.*, **40,** 133–4 (1947).
(5) Rodriguez, J. G., and Gould, W. A., *Ibid.*, **43,** 498–503 (1950).
(6) Rohwer, S. A., *Agr. Chemicals*, **4,** 35, 75, 77 (1949).
(7) Stitt, L. L., and Evanson, J., *J. Econ. Entomol.*, **42,** 614–17 (1949).
(8) Tukey, J. W., *Biometrics*, **5,** 99–114 (1949).
(9) U. S. Interdepartmental Committee on Pest Control, "Lindane, a Coined Name for the Pure Gamma Isomer of Benzene Hexachloride," 1949.

Received for review March 17, 1953. Accepted May 4, 1953.