PESTICIDES AND FLAVOR

Effect of Benzene Hexachloride Sprays on the Flavor of Fresh, Frozen, and Canned Peaches

GLADYS L. GILPIN and ELSIE H. DAWSON, Human Nutrition Research Branch
EDOUARD H. SIEGLER, Entomology Research Branch
Agricultural Research Service, U. S. Department of Agriculture, Beltsville, Md.

Flavor tests were made on peaches from trees sprayed with four component isomers of technical benzene hexachloride—alpha, beta, gamma, and delta—used individually and also combined as a mixture, or sprayed with commercial gamma isomer. Two dosages of the insecticides were studied. The most pronounced musty or earthy off-flavors were found in the peaches from trees sprayed with a mixture of the isomers. Off-flavors were noted rather consistently in the different samples of canned and frozen peaches from lots grown on trees sprayed with the delta isomer. In peaches from trees sprayed with the other isomers of benzene hexachloride, flavor was not appreciably different in most instances from that of the untreated control sample. Stored samples of canned and frozen peaches appeared to have more off-flavor than freshly canned or frozen samples. In general, canned samples had the highest incidence of off-flavor, frozen samples less than canned, and raw samples the least.

OFF-FLAVORS HAVE BEEN REPORTED in peaches which were treated with the insecticide benzene hexachloride during the growing season (*1–13*). The form in which the fruit was eaten, as raw, canned, or frozen, appeared to have some effect on the amount of off-flavor detected. Time of application and dosage of insecticide were found to affect incidence of off-flavor in the peaches, and the composition or formulation of the benzene hexachloride spray also influenced results. The present study was made to determine the individual effects of the principal component isomers of technical benzene hexachloride and to study further the effect of dosage of the insecticide on the flavor of peaches when eaten raw, canned, and frozen.

Procedure

Four pure isomers of benzene hexachloride—alpha, beta, gamma, and delta—were tested individually in the proportions in which they occur in the parent technical form and also combined as a mixture in the same proportions. The isomers were prepared by recrystallization from organic solvents and checked for purity by melting point determination and by infrared spectrometer analysis. Table I includes the per cent purity of the isomers studied. 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.

Halehaven variety peaches grown on the Eastern Shore of Maryland in 1948 were sprayed July 23 with the above preparations in the single-strength dosages given in Table I, and other trees of the same variety were sprayed the following day with double-strength dosages of the same preparations. The single-strength sprays contained approximately the amounts of the isomers which would be present in the dosage recommended for spraying peach trees; double-strength sprays were included to test the effect of a heavy dosage of insecticide. All trees were sprayed to the point of runoff (about 2 to 5 gallons of spray per tree, depending on the size of the tree). Peaches from untreated trees were included as labeled reference and coded control samples. All samples were provided by the Bureau of Entomology and Plant Quarantine, which supervised the spraying and harvesting of the peaches.

Weather conditions during the growing season were very unsatisfactory, with considerable rain, and the crop had to be harvested when only partially ripe, as the fruit was falling from the trees.

The peaches were picked August 10 and delivered to the laboratory the same day. The samples which had been sprayed with the single-strength dosage of insecticide were placed in one layer on trays and held at room temperature overnight to ripen. Samples which received the double-strength dosage were placed in cold storage at 38° F., where they were held for 24 hours; prior to use they also were allowed to ripen overnight at room temperature. Because of brown rot it was difficult to ripen the peaches before they spoiled. Consequently, it was necessary to use the peaches before the optimum stage of maturity was attained.

All peaches were washed once in tap water and once in distilled water and drained well. Clean equipment was used for each sample to prevent carryover of flavors. The peaches were halved, pitted, pared, and sliced into sixths or eighths, depending on size.

For the frozen pack, 350 grams of sliced peaches and 90 ml. 40% sugar sirup containing 132 mg. of ascorbic acid were packed in pint freezer jars and frozen immediately at 0° F. in air circulated by an electric fan. The frozen samples were stored in still air at 0° F., except for one container from each treatment, which was stored at −40° F.

For the canned pack, the pared peach halves were held for a few minutes in a solution of 2 tablespoons of vinegar and 2 tablespoons of salt per gallon of distilled water to retard darkening of the fruit. The peaches were drained, sliced, and packed raw into pint glass canning jars, each jar containing 350 grams of fruit and 90 ml. of 40% sirup. Sample lots from each different spray treatment were processed individually in a freshly prepared boiling water bath for 25 minutes at 212° F. Samples of each treatment were stored at 32° and 75° F.

Palatability tests were conducted on raw sliced peaches and on frozen and canned peaches when freshly processed and after storage for 8 months. Ratings for frozen peaches stored at −40° and 32° F. were combined, and those for canned peaches stored at 32° and 70° F., as there were no apparent differences which could be attributed to storage temperature. The panel consisted of 5 to 7 persons who previously had learned to recognize off-flavors due to benzene hexachloride by training on known samples of treated peaches. The total number of judgments for each treatment, derived by multiplying the number of samples by the number of panel members, is listed in Table II.

Each panel member was asked to describe any off-flavor detected in coded samples. The percentage of judgments in which off-flavors were identified by the panel as musty or earthy was calculated. These percentages were subjected to the angular transformation and treated by analysis of variance.

Table I. Treatments and Dosages of Benzene Hexachloride Spray

Treatment	Lb. Insecticide/100 Gallons Spray
Control (untreated)	0.0
Single-strength spray	
Commercial gamma (97.7% gamma)	0.265
Alpha isomer (99.8%)	1.30
Beta isomer (99.96%)	0.20
Gamma isomer (99.98%)	0.26
Delta isomer (99.93%)	0.18
Mixture of alpha, beta, gamma, and delta isomers[a]	2.00
Double-strength spray	
Commercial gamma (97.7% gamma)	0.53
Alpha isomer (99.8%)	2.60
Beta isomer (99.96%)	0.40
Gamma isomer (99.98%)	0.52
Delta isomer (99.93%)	0.36
Mixture of alpha, beta, gamma, and delta isomers[a]	4.00
[a] Analysis of mixture of isomers (%)	
Gamma	13
Alpha	65
Beta	10
Delta	9
Epsilon and impurities	3
Total	100

Results

Because the number of judgments varied for the different samples, both the number of times musty or earthy off-flavors were noted and the percentage of judgments in which these off-flavors were detected in raw, canned, and frozen peaches are included (Tables II and III).

Some off-flavors similar to those caused by benzene hexachloride contamination were noted in peaches from untreated trees. It is difficult to isolate clearly off-flavors attributable to a specific treatment from those associated with immature, underripe, or partially spoiled products. Unless more off-flavors were noted in samples from treated trees than in the one from untreated trees, it was assumed that off-flavors were probably due to the quality of the peaches rather than to the insecticide.

The high incidence of off-flavors found in some of the samples in this study may be due to the late spraying, which occurred only about 18 days before harvest. Several papers (*3*, *4*, *7*, *9*) include statements that off-flavors were more noticeable as sprays were applied nearer to harvest, and Bobb (*2*) indicated off-flavors in the fruit when harvest was as much as 4 weeks after application of benzene hexachloride. Bailey, Esselen, and Wheeler (*1*), on the other hand, reported no apparent relationship between the intensity of the undesirable flavors due to benzene hexachloride and the elapsed time between the last spray and picking; Davis (*5*) came to the same conclusion.

Among the samples tested raw it appears that only the mixture of isomers gave much indication of causing off-flavor in the peaches. Off-flavors were noted more often when the mixture was used as a double-strength than as a single-strength spray. Other investigators (*4*, *7*, *9*) have found that there was

Table II. Detection of Benzene Hexachloride Off-flavors in Raw, Canned, and Frozen Peaches

(From plots sprayed with various benzene hexachloride preparations and from untreated plots)

	Raw		Canned				Frozen			
			Freshly Canned		Stored 8 Months		Freshly Frozen		Stored 8 Months	
Treatment	Total No.[a]	No. off-flavors	Total No.[a]	No. off-flavors	Total No.[a]	No. off-flavors	Total No.[a]	No. off-flavors	Total No.[a]	No. off-flavors
Control (untreated)	11	1	24	2	48	17	28	2	46	10
Single-strength spray										
Commercial gamma isomer	5	0	13	0	23	4	14	2	12	3
Alpha isomer	5	0	13	0	23	7	14	0	12	
Beta isomer	5	0	13	0	23	7	14	0	12	2
Gamma isomer	5	0	13	0	23	13	14	3	12	1
Delta isomer	5	1	13	3	23	10	14	2	12	4
Mixture of isomers	5	2	13	6	23	17	14	5	12	5
Double-strength spray										
Commercial gamma isomer	6	0	11	1	24	9	14	1	11	2
Alpha isomer	6	0	11	1	24	9	14	1	11	2
Beta isomer	6	1	11	4	24	12	14	2	11	3
Gamma isomer	6	0	11	2	24	7	14	1	11	0
Delta isomer	6	0	11	3	24	14	14	5	11	7
Mixture of isomers	6	4	11	5	24	24	14	5	11	7

[a] Samples X panel members.

Table III. Detection of Benzene Hexachloride Off-flavors in Raw, Canned, and Frozen Peaches

(From plots sprayed with various benzene hexachloride preparations and from untreated plots)

Treatment	Raw, %	Canned, %		Frozen, %	
		Freshly canned	Stored 8 months	Freshly frozen	Stored 8 months
Control (untreated)	9	8	36	7	22
Single-strength spray					
Commercial gamma isomer	0	0	17	14	25
Alpha isomer	0	0	30	0	33
Beta isomer	0	0	30	0	17
Gamma isomer	0	0	57	21	8
Delta isomer	20	23	43	14	33
Mixture of isomers	40	46	74	36	42
Double-strength spray					
Commercial gamma isomer	0	9	38	7	18
Alpha isomer	0	9	38	7	18
Beta isomer	17	36	52	14	27
Gamma isomer	0	18	29	7	0
Delta isomer	0	27	58	36	64
Mixture of isomers	67	45	100	36	64

an increase in intensity of off-flavor as the number of applications of the insecticide was increased.

In general, off-flavors were noted more often in canned than in raw or frozen peaches. This observation agrees with that of Bailey, Esselen, and Wheeler (*1*), who reported off-flavors in canned peaches but none in fresh or frozen peaches from 36 varieties treated with benzene hexachloride. They suggest that heating may bring out the off-flavor in peaches which have been sprayed with benzene hexachloride. Cochran and Van Blaricom (*4*) found that both the refined and technical benzene hexachloride compositions they tested affected the flavor of canned peaches, but only the technical materials affected the frozen product. They also found that more applications of the insecticide were required to produce off-flavor in frozen peaches than in canned. Davis (*5*) reported that off-flavors were detected by at least some of the judges in all samples of canned peaches prepared from fruit sprayed with benzene hexachloride.

As with the raw samples, off-flavors were found most often in freshly canned peaches when the mixture of isomers was used in single- or double-strength dosages. Delta isomer may have had some effect on the flavor of the freshly canned peaches, since off-flavor was noted in about one fourth of the judgments when both single- and double-strength sprays were used. Some off-flavors also were noted in freshly canned samples from lots of fruit sprayed with double-strength dosages of beta and gamma isomers of benzene hexachloride. The fact that off-flavors were a greater problem with the mixture of isomers than with the pure gamma isomer is in agreement with other studies on peaches (*4, 7, 13*) where technical benzene hexachloride was compared directly with the refined gamma isomer of benzene hexachloride. In the present study, the heavier dosage of insecticide used in the mixture than in the pure gamma isomer spray may be the reason for more off-flavor.

Stored canned peaches had more off-flavors than freshly canned peaches. Again, more off-flavors were noted in samples on which the mixture of isomers was the insecticide used; the evidence shows definitely that this treatment is undesirable for peaches to be canned and stored. Because off-flavors were noted in both freshly canned and stored canned peaches from trees treated with single- or double-strength delta isomer sprays, it is possible that elimination of the delta isomer might decrease the tendency of the insecticide mixture to produce off-flavors. Double-strength dosages of beta isomer spray also may have caused off-flavors in stored canned peaches. The data are not conclusive as to whether or not gamma isomer is responsible for flavor damage in stored canned peaches. Indications are that neither alpha isomer nor commercial gamma isomer was responsible for the flavor defects noted in the stored canned samples, since data for these samples and for the stored control sample were comparable.

As was true with raw and canned samples, the most off-flavors in freshly frozen peaches also were detected in samples from trees sprayed with the mixture of isomers. It appears that delta isomer may affect the flavor of freshly frozen peaches somewhat, especially when used as a double-strength spray. Data for the other isomers do not indicate clearly that serious off-flavors were present in those samples.

Generally, more off-flavors characteristic of benzene hexachloride were detected in frozen peaches stored 8 months than in freshly frozen peaches. Off-flavors in stored frozen peaches were noted most often in samples from trees sprayed with the mixture of isomers or with delta isomer of benzene hexachloride. It is questionable whether stored frozen peaches from lots grown with any of the other isomers had off-flavors noted a sufficient number of times to indicate contamination of flavor.

Relatively greater increase in incidence of off-flavors in stored treated samples as compared with stored controls suggests that the flavor of benzene hexachloride residues becomes accentuated during storage of either canned or frozen peaches.

Acknowledgment

The authors wish to express thanks to Mildred G. Staley, Human Nutrition Research Branch, Agricultural Research Service, and to former staff members Olivia A. Hammerle, Suzanne S. Alexander, and M. Patricia Trimble for valuable assistance in the laboratory. The authors are indebted to Albert B. Parks and Elsie F. Dochterman, Human Nutrition Research Branch, for statistical analysis of the data.

The insecticide materials for the study were furnished by the California Spray-Chemical Corp., Richmond, Calif.

Literature Cited

(1) Bailey, J. S., Esselen, W. B., Jr., and Wheeler, E. H., *J. Econ. Entomol.*, **42,** 774 (1949).
(2) Bobb, M. L., *Proc. Va. State Hort. Soc., 51st Ann. Meeting*, 47 (1946).
(3) Chandler, S., *Down to Earth*, **4,** 14 (1948).
(4) Cochran, J. H., and Van Blaricom, L. O., *Food Packer*, **31,** 30 (1950).
(5) Davis, L. L., *Ibid.*, **29,** 35 (1948).
(6) Gould, W. A., Sleesman, J. P., Rings, R. W., Lynn, M., Krantz, F., Jr., and Brown, H. D., *Food Technol.*, **5,** 129 (1951).
(7) Rings, R. W., Gould, W. A., and Dunnigan, M., Ohio Agr. Expt. Sta., Dept. Entomol., *Pub. Series* **10** (1949).
(8) Smith, C. F., Jones, I. D., Calvin, L. D., *J. Econ. Entomol.*, **43,** 179 (1950).
(9) Smith, C. F., Jones, I. D., and Rigney, J. A., *Ibid.*, **42,** 618 (1949).
(10) Snapp, O. I., *Ibid.*, **40,** 382 (1947).
(11) *Ibid.*, **41,** 569 (1948).
(12) *Ibid.*, **42,** 7 (1949).
(13) *Ibid.*, **44,** 504 (1951).

Received for review January 21, 1954. Accepted June 12, 1954.