Removal of DDT, Malathion, and Carbaryl from Tomatoes by Commercial and Home Preparative Methods

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Tomatoes grown on three separate plots were treated with DDT, malathion, and carbaryl. After harvesting, they were prepared for serving by commercial canning, home canning, and kitchen procedures and residue determinations were made at appropriate points. Commercial canning and juicing operations removed virtually all DDT, malathion, and carbaryl residues. Home canning of whole tomatoes and tomato juice removed all but trace amounts of DDT and malathion. Approximately 8% of the carbaryl residue remained in the canned whole tomatoes and 23% remained after the home canning of juice. Home cooking removed 85% of the DDT residue, 96% of the malathion residue, and 69% of the carbaryl residue. The raw, unwashed fruit stored at 55° F. suffered no significant decrease in DDT or carbaryl; however, an apparent malathion decrease of 30% was noted in a 7-day storage period.

Limited data on the effect of washing and processing on residues of DDT [1,1,1-trichloro-2,2-bis(*p*-chlorophenyl)ethane] in various fruits and vegetables have been collected (Bohm *et al.*, 1950; Brittin and Fairing, 1950; Carlin *et al.*, 1966; Haller and Carter, 1950; Lamb *et al.*, 1948, 1950; Manalo *et al.*, 1946; Miller *et al.*, 1957; Tressler, 1947). The colorimetric methods utilized for many of the earlier studies could not separate and detect all of the isomers and breakdown products with the ease now available from chromatographic methods. Carter (1948) studied the effect of cooking on DDT in beef. Farrow *et al.* (1966) reported on the conversion of *p,p'*-DDT to *p,p'*-TDE [2,2-bis(*p*-chlorophenyl)-1,1-dichloroethane] during the processing of canned spinach. Other work published recently reflects growing interest in the effect of food preparative steps on pesticide residues (Hemphill *et al.*, 1967; Koivistoinen *et al.*, 1964a, 1964b, 1964c, 1965a, 1965b, 1965c, 1965d). The effect of food preparative steps on malathion and carbaryl residues has not been studied.

EXPERIMENTAL

Pesticide Application. Tomatoes of the VF 145-21-4 variety were field grown near Woodland, Calif., during the 1965 season. This is a machine-harvested variety and cultural practices considered optimum for machine harvesting were followed. The field was irrigated seven times, the last on August 5. There was no significant rainfall during this period.

The plots used for this experiment consisted of a single row 400 feet long, divided into three equal sections. They were staked out and the first application of all three pesticides was made to separate plots on September 27, 1965. The plots were sprayed with a Hudson Sprayer, equipped with flat spray nozzles on triple boom heads, containing about 1.5 gallons of diluted spray which was equivalent to about 100 gallons of spray per acre.

National Canners Association, Washington, D.C., and Berkeley, Calif.

The following treatments were applied:

Plot No. 1—DDT 50% wettable powder (Ortho)

September 27	5.8 pounds per acre
October 4	4.4 pounds per acre
Harvested	October 4

Plot No. 2—Carbaryl Stauffer Flowable Sevin 4, 4 pounds per gallon, 41.8% active

September 27	6.2 pounds per acre
October 6	6.0 pounds per acre
Harvested	October 6

Plot No. 3—Malathion 50% emulsifiable concentrate (Ortho)

September 28	6.5 pounds per acre
October 4	9.8 pounds per acre
October 6	8.3 pounds per acre
October 11	8.5 pounds per acre
Harvested	October 11

Pesticide treatments were applied closer to harvest than usual, to ensure the presence of residues at or slightly in excess of tolerances established by the Food and Drug Administration. The field was harvested the same day as sprayed, allowing a short time for the spray to dry before picking the fruit. The tomatoes were picked directly into polyethylene bags which were packed into fiberboard boxes for shipment. Approximately 300 pounds of tomatoes were harvested from each experimental plot, half of which were shipped to Washington, D.C., by air express on the afternoon of the day they were harvested. The remainder were held overnight in the Berkeley laboratory and processed the next day.

Commercial Preparation. Tomatoes were subjected to commercial canning procedures using equipment available at the Berkeley laboratory. This includes an experimental washer and blancher specially constructed to simulate commercial operations on a pilot plant scale. The apparatus consists of three units: an immersion spray washer, an inclined spray washer, and a blancher. The residence time in each unit, the temperature, and the pressure of sprays can be controlled independently. Water is

recirculated in each of the units. A rotary spray washer was constructed to fit into the blancher unit to provide a third type of washing operation.

Commercial processing procedures are diagramed in Figure 1. Before washing, three random samples, each consisting of approximately 12 tomatoes and weighing about 3 pounds, were blended in a large Waring Blendor and a portion filled into a No. 303 can, sealed, and frozen.

The tomatoes were divided into four portions, and subjected to minimum and maximum washes, with and without a detergent.

1. Approximately 50 pounds were soaked 3 minutes in cold water, run through the spray immersion unit of the experimental washer for 23 seconds, and passed through the spray washing unit for 10 seconds. Cold water sprays were under 30 pounds of pressure.
2. Approximately 50 pounds of tomatoes were treated similarly except that 0.1% Tergitol 08 was added to the spray immersion washer.
3. Approximately 25 pounds of tomatoes were soaked 3 minutes in cold water, then run through the spray immersion unit for 65 seconds, sprayed for 35 seconds, and then run through the rotary spray washer for $1^1/_2$ minutes with water at 80° to 85° F.
4. Approximately 25 pounds of tomatoes were treated as in 3 above, except that 0.1% Tergitol 08 was added to the spray immersion unit.

Triplicate samples each consisting of 12 tomatoes or about 3 pounds were taken for analysis after each washing treatment. All samples were blended in a Waring Blendor and representative portions filled into No. 303 cans, sealed, and frozen.

The tomatoes from washing treatments 1 and 2 were divided into two portions, one of which was peeled and the other made into juice. The tomatoes given washes 3 and 4 were juiced only.

Tomatoes were peeled by exposure to live steam in a chamber for 60 seconds followed by spraying with cold water for 60 seconds. The peels were removed by hand (cores were not removed since the VF variety does not contain objectionable core material), sealed into No. 303 cans, and frozen. The peeled tomatoes were filled into No. 303 cans, a 25-grain NaCl-$CaCl_2$ tablet added, and the cans exhausted for 10 minutes at 200° to 210° F. The cans were filled completely with hot tomato juice (200° to 210° F.) made from the same lot of tomatoes, closed at atmospheric pressure using a Rooney semiautomatic can closing machine, and processed in a still retort for 35 minutes at 212° F. followed by water cooling to 100° to 110° F.

Tomatoes for juicing were cut into two pieces, and placed in a stainless steel jacketed kettle where they were stirred and heated to 180° to 190° F. They were then run through a pilot plant model Langsenkamp juice extractor with a 0.033-inch screen. The juice was collected in buckets and transferred back to the steam-jacketed kettle where it was reheated to 200° to 212° F., filled into No. 303 cans, a 25-grain salt tablet added, and the cans closed. The cans were processed for 35 minutes at 212° F. in a retort and water cooled. The waste tomato pulp remaining after the juicing operation was filled into a No. 303 can, sealed, and frozen.

Home Preparation and Storage. Home preparative steps and cooking procedures were carried out under the direction and general supervision of professional home economists. About 150 pounds of pesticide-treated tomatoes were received at the Washington laboratory on the day following harvest; at that time all samples connected with the washing, home canning, and peeling experiments were extracted for residue analysis. All samples connected with the home cooking experiments were extracted 4 days after harvest.

Home preparative operations are diagramed in Figure 2. For the washing and subsequent canning experiments, approximately 50 pounds of tomatoes were composited and washed. At the completion of each home cooking operation, the samples were immediately extracted and the extracts stored at reduced temperature until the analyses could be completed.

After 3 days of storage at 55° F., three samples of tomatoes, consisting of about $1^1/_2$ pounds each, were selected for the preparation of stewed tomatoes. These were washed, the stem ends and peel removed without heating by trimming with a knife, and the fruit was then quartered, heated to boiling in its own juice, and simmered for 10 minutes. Each sample was homogenized in a Waring Blendor, and two subsamples were withdrawn for residue determination and two for total solids determination.

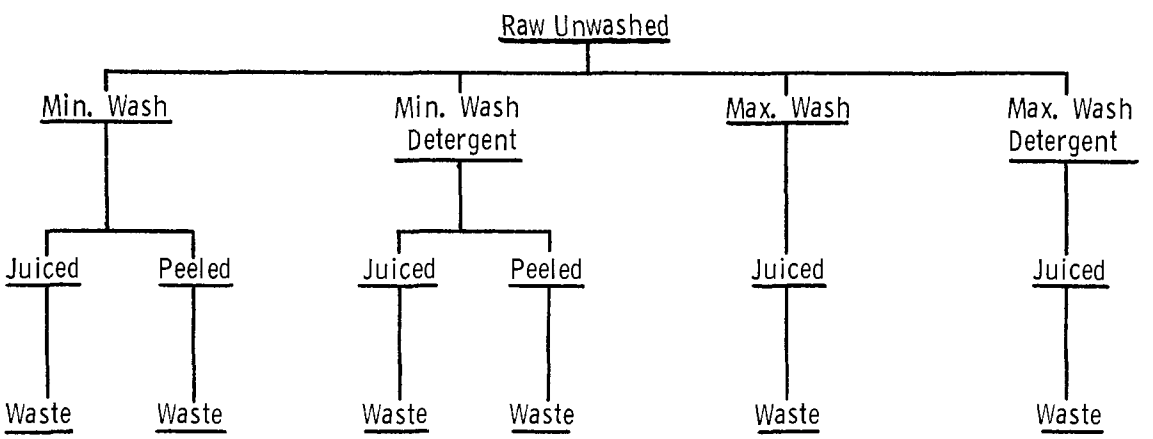

Figure 1. Sampling points for commercial processing procedures

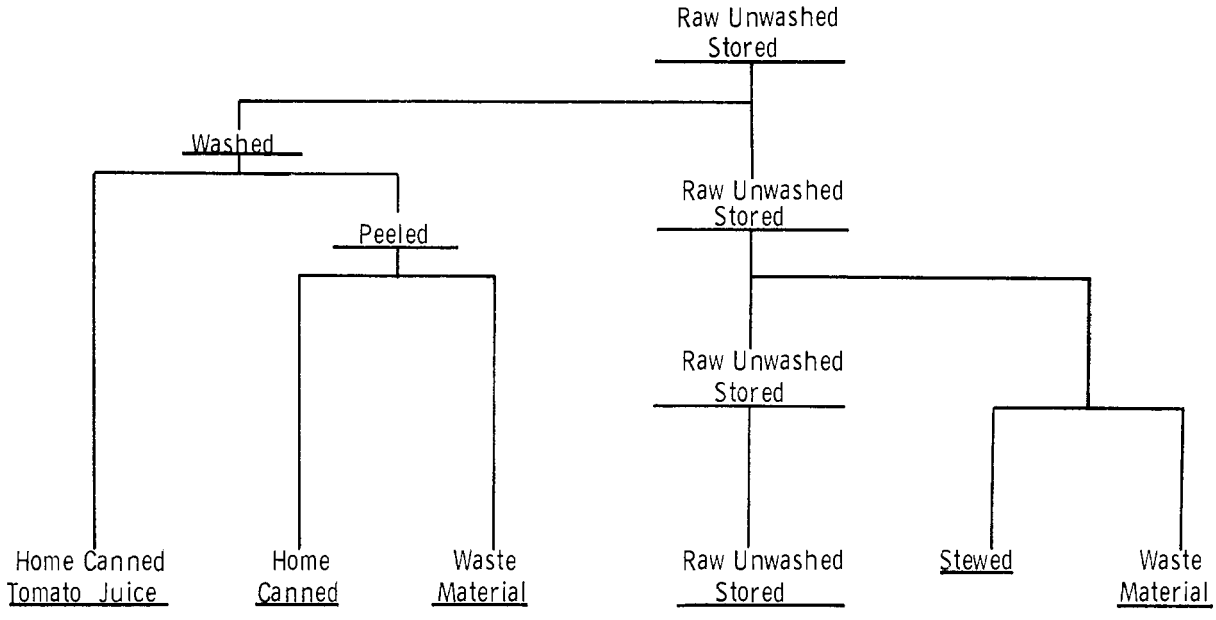

Figure 2. Sampling points for tomato home preparative procedures

To follow the decrease of pesticide residue on the raw, unwashed fresh fruit, samples were taken at intervals of 3 or 4 days throughout the longest period consistent with obtaining fruit of reasonable quality. The raw fruit was sampled three or four times covering a total period of from 10 to 12 days after harvest. Since the fruit was harvested at a ripeness suitable for canning, longer storage periods were not practical. The sampling dates for the three lots of tomatoes are tabulated below.

	DDT	Carbaryl	Malathion
Harvested	October 4	October 6	October 11
Sampled	October 5	October 7	October 12
	October 9	October 11	October 15
	October 11	October 14	October 18
			October 21

Analytical Methods. The procedure used in both laboratories for the extraction and clean-up of DDT was essentially that of Mills (1959). Petroleum ether extracts were stored at reduced temperatures until Florisil column clean-up and analysis by electron-capture gas liquid chromatography. Extracts were chromatographed in a Packard 800 or a Wilkens Hy Fi, on 6-foot × 1/4-inch or 10-foot × 1/8-inch borosilicate glass columns packed with a mixture of equal amounts of 10% DC 200 silicone grease and 15% QF-1 on Gas Chrom Q (Burke and Holswade, 1966). Both were operated at 200° F. with a nitrogen flow rate of 120 and 40 ml. per minute in the Packard and the Wilkens, respectively. Recoveries of technical DDT from raw, unpeeled tomatoes and from the waste tomato pulp from juicing varied from 80 to 110%.

Tomatoes treated with malathion were analyzed by gas chromatography (Giuffrida, 1964) following a sweep co-distillation clean-up procedure (Storherr and Watts, 1965). Recoveries of malathion from raw, unpeeled tomatoes fortified at 2, 5, and 7 p.p.m. were in the range of 78 to 95%.

The analytical procedure used for the determination of carbaryl residues was that of Benson and Finocchiaro (1965). Recoveries of carbaryl were low at low residue levels and increased in proportion to the increase in level. The recoveries ranged from 60% at 0.2 p.p.m. to 90% at 4 p.p.m.

RESULTS AND DISCUSSION

Sample Variation and Residue Content during Storage. The data on DDT residues in unwashed tomatoes are entered in Table I together with values obtained after storage at 55° F. for 4 and 7 days.

An analysis of variance was performed on these data to isolate the sample variation and to investigate the significance of any differences in total DDT content among storage periods. A statistically significant effect due to storage was not demonstrated. The data were analyzed to provide estimates of the sample and analytical variation. The standard deviation of a single sample was 1.2 p.p.m. and the standard deviation of a single determination was 0.5 p.p.m. The agreement between duplicates was good considering the fact that the estimate of total DDT is the sum of determinations of two DDT isomers and DDE.

Variations among individual samples taken from a lot of pesticide-treated fruit are not surprising in view of the large

Table I. Behavior of DDT Residues during Storage of Tomatoes at 55° F.

Days after Harvest	*p,p'*-DDE	*o,p'*-DDT	*p,p'*-DDT	Total DDT
One	0.05	0.90	3.4	4.4
Confidence limits[a]		0.125	0.361	0.318
Four	tr.	0.64	3.0	3.7
Confidence limits[a]		0.247	1.08	1.29
Seven	tr.	0.60	3.1	3.8
Confidence limits[a]		0.173	0.789	0.945

[a] 95% confidence limits (wet basis) = SD (Student's t at 0.05)/$\sqrt{N}$. tr. = Trace, less than 0.05 p.p.m.

differences that must exist in the amount of pesticide present in individual fruits. Although the pesticide was uniformly applied to the top surfaces of the plants, the exposure of individual fruit is highly variable. The VF-145 variety of tomatoes produces clusters of fruit at various levels. Bottom clusters may receive little or no exposure to the spray, since they are protected by leaves and fruit at the upper levels. The fruit was mixed before samples were taken; however, the perishable nature of the crop does not permit excessive handling and the size of the fruit limits the number of units that can be included in each sample.

The data collected on malathion residues in tomatoes during storage are in Table II. There was an apparent decrease of about 30%; however, an analysis of variance did not demonstrate a significant difference in the residue level during the 7-day interval of storage. The sample standard deviation was 2.5 p.p.m., about 30% of the mean. DDT results also showed a sample standard deviation of about 30%. The malathion-containing tomatoes were subject to the experimental problems and errors described above.

Results of the effect on carbaryl of storage for 7 days are shown in Table II. A statistically significant storage effect is not demonstrated. The sample variance is of the same order of magnitude as the storage variance. The sample standard deviation was 2.5 p.p.m., 33% of the mean, and comparable to sample standard deviations of 30% for DDT and malathion samples.

Table II. Behavior of Malathion and Carbaryl during Storage of Tomatoes at 55° F.

Residues in p.p.m.

	Days in Storage		
	1	4	7
Malathion	6.28	5.18	4.42
Confidence limits	1.38	1.94	1.03
% decrease		18	30
Carbaryl	8.36	6.5	8.18
Confidence limits	3.15	1.11	2.44
% decrease		22	2

Removal of DDT by Commercial Preparative Procedures. The results obtained on DDT residues after various steps in the commercial processing experiments are shown in Table III. The amount of *p,p'*-DDE [1,1-dichloro-2-bis-(*p*-chlorophenyl)ethylene] was found to be less than 0.1 p.p.m.; hence, values for this compound are not reported.

The water wash removed from 85 to 92% of the residue, there being no significant difference between the two washing treatments employed with or without detergent. The results indicate that DDT residues present on the surface of tomatoes are easily removed by water washing, but DDT that has penetrated into the skin cannot be removed to any significant extent by increasing the efficiency of the wash.

Removal of peels whether by steam peeling in the case of whole peeled tomatoes or by screening in the case of tomato juice removed all but a trace of the residue. In all instances, removal of residue was 99% or better. The manner of washing and the efficiency of the wash within the range of conditions employed in this experiment would not appear to be factors in the amount of residue in the final product.

The amount of DDT found in peelings and in waste from juicing operations shows that this residue, located primarily in the tomato skin, is not transferred to juice by the hot break procedure used in preparation of tomato juice. The actual concentration of DDT in waste pulp remaining after juicing operations is dependent on the amount of liquid extracted from the pulp. In a commercial operation, the concentration of DDT in waste pulp would be higher than that shown in these studies, since extraction of juice in a batch-type operation is less complete than that obtained in a continuous operation, after the equipment has reached optimum operating conditions.

Table III. Removal of DDT from Tomatoes by Commercial Procedures

Residues in p.p.m.

Treatment	Total Solids	*p,p'*-DDT	*o,p'*-DDT	Total DDT and Related Compounds	Confidence Limits	% Decrease	
						Wet	Dry
Unwashed	5.16	5.6	2.1	7.7	1.2		
Minimum wash	4.9	0.44	0.38	0.82	0.16	89	89
Minimum wash det.	4.53	0.62	0.54	1.16	0.21	85	83
Maximum wash	4.61	0.33	0.34	0.67	0.13	91	91
Maximum wash det.	4.53	0.31	0.29	0.60	0.13	92	91
Minimum wash peeled-canned		tr.	tr.	tr.		99+	99+
Peels	6.72	4.2	4.1	8.3			
Minimum wash juice-canned	4.94	tr.	tr.	tr.		99+	99+
Waste		7.2	7.0	14.2			
Maximum wash juice-canned	4.97	tr.	tr.	tr.		99+	99+
Waste		6.0	6.4	12.4			
Maximum wash det. juice-canned	4.56	tr.	tr.	tr.		99+	99+
Waste	4.34	5.9	6.1	12.0			

tr. = Trace, less than 0.05 p.p.m.

In residue found on the unwashed tomatoes, the distribution of isomers approximates that present in technical DDT. The DDT used in these studies contained approximately 64% *p,p'*-DDT and 27% *o,p'*-DDT. After washing, a higher ratio of *o,p'*-DDT to *p,p'*-DDT was found. This would indicate that *p,p'*-DDT is more easily removed than *o,p'*-DDT, and that smaller portions of *p,p'*-DDT penetrate into the tomato skin. This altered ratio was also found in skins and waste from juicing operations where almost equal amounts of *o,p'*- and *p,p'*-DDT were found.

Removal of DDT Residues by Home Preparative Steps. Data obtained in the home preparative experiments are presented in Table IV. The original residue of 4.4 p.p.m. was reduced to 0.94 p.p.m. by cold water wash, a 78% decrease. This compares with the 89 to 92% removal by the more rigorous commercial washing. Peeling by immersion in boiling water removed virtually all detectable quantities of DDT.

The results of the analyses of the home canned tomatoes were in agreement with results on commercially peeled canned tomatoes. Only trace quantities of *p,p'*-DDT were obtained at the borderline of reliable detectability. In the discarded peelings the DDT concentration remained at an average level of 8 p.p.m. in spite of the boiling water treatment. This amount of DDT constitutes the major portion of pesticide remaining on the fruit after the cold water wash. The results are entirely in line with observations made on commercial tomato waste material which is likely to contain appreciable quantities of any wax-soluble pesticides remaining on the product after harvest.

The home cooking procedures were carried out after the fruit had been held for 3 days at 55° F., and in parallel with first sampling of the stored fruit (see Figure 2). The results indicate that 85% of the total DDT is removed during washing and cooking procedures. Appreciably more DDT remained in the stewed tomatoes than in any other home or commercially prepared sample. One possible explanation for this observation is the difference in the peeling procedure used in this instance. In the other commercial and home preparative experiments, the fruit was peeled by scalding either in steam or hot water. In either case the peels were slipped easily with a minimum of handling. The tomatoes to be stewed were trimmed and peeled without heating, thereby requiring considerably more handling.

In the hand peeling and quartering operations there may be some mechanical transfer of a loosely held surface residue that may not have been completely removed by the cold water wash. Commercial experience and results obtained in commercial canning and home cooking experiments indicate that DDT residues that have penetrated into the skin are held very tenaciously. The hand peeling operation, however, requires considerable handling of both peeled and unpeeled portions of the fruit and some mechanical transfer could occur. The loss of liquids during hand peeling of the tomatoes, and the loss of moisture during cooking would also contribute to a slightly higher residue level in stewed tomatoes.

The existence of a statistically significant difference between results obtained on unwashed commercial samples and unwashed home preparative samples is acknowledged. A portion of this difference may be attributed to the additional handling required to transport the home preparative samples to Washington; however, a real laboratory effect was probably present. Prior experience with collaborative analyses of pesticide residue samples suggested that such effects were not unlikely, and they were anticipated when the present work was designed. Direct comparisons involving results of both laboratories have not been attempted. Results within each laboratory are consistent and the validity of the data on DDT removal is not affected.

Malathion Removal. The results obtained on malathion residues after various steps in commercial preparation of canned tomatoes and tomato juices are shown in Table V. Home preparative results are collected in Table VI.

The per cent removal by washing was affected to a certain extent by the initial level of malathion on tomatoes, being greater the higher the initial level. Probably, malathion remaining on the raw product after weathering would be considerably more difficult to remove by washing than malathion recently applied. The results of this experiment are more significant from the standpoint of the actual amount of malathion remaining on tomatoes after washing than from the standpoint of the per cent removed. Had the initial level of malathion been lower, proportionately less of it would probably have been removed. This expectation is supported by the home washing and peeling studies. Unwashed samples used for home preparative studies contained about 6.3 p.p.m. After home-style washing, malathion content averaged 6.0 p.p.m. Peel-

Table IV. Removal of DDT from Tomatoes by Home Preparative Procedures

		Residues in p.p.m.					
Treatment	Total Solids	*p,p'*-DDE	*o,p'*-DDT	*p,p'*-DDT	Total DDT and Related Compounds	Confidence Limits	% Decrease Wet
Unwashed	4.62	0.05	0.9	3.4	4.4	0.32	
Washed	4.6	tr.	0.34	0.61	0.94	0.10	78
Canned		nd	nd	tr.	tr.		99+
Juice		tr.	tr.	nd	tr.		99+
Unwashed		tr.	0.64	3.0	3.7	1.29	
Stewed		nd	nd	0.57	0.57	0.25	85

tr. = Trace, less than 0.05 p.p.m.—0.03 used for averages.
nd = Not detected.

Table V. Malathion Removed from Tomatoes by Commercial Processing

Treatment	Total Solids	Average	Confidence Limits	% Decrease Wet	% Decrease Dry
Unwashed	4.6	15.9	0.59		
Washed					
W 1	4.4	1.5	0.15	91	90
W 1 D	4.6	2.7	0.32	83	84
W 2	4.5	0.8	0.06	95	95
W 2 D	4.7	1.7	0.13	90	90
Processed (whole)					
W 1	4.8	0.10		99+	99+
W 1 D	4.7	0.09		99+	99+
Canned juice					
W 1	4.8	0.12		99+	99+
W 1 D	4.8	0.11		99+	99+
W 2	4.8	0.14		99+	99+
W 2 D	5.4	0.10		99+	99+

W 1 = Minimum wash.
W 1 D = Minimum wash with detergent.
W 2 = Maximum wash.
W 2 D = Maximum wash with detergent.

Table VI. Removal of Malathion from Tomatoes by Home Preparative Procedures

Treatment	Total Solids	Average	Confidence Limits	% Decrease Wet	% Decrease Dry
Unwashed	5.34	6.3	1.38		
Washed	5.29	6.1	1.48	4	3
Peeled		0.38	0.24	94	
Stewed		0.24		96	
Canned (whole)		nd		99+	
Canned (juice)	6.41	nd		99+	99+

nd = Not detected.

ing removed virtually all of the residue, and sizable proportions of malathion remained in the discarded trim.

The differences between results of the home and commercial preparative experiments emphasize the need for caution in generalizing on the results of pesticide removal experiments of this type. Our results suggest that during shipment from Berkeley to Washington, considerable additional quantities of malathion penetrated from the surface to the waxy layers adjacent to the tomato skin. As a consequence, the cold water wash used in the home preparative study was virtually ineffective in removing the residue. For this pesticide-product combination, the fraction removed by washing may be greatly influenced by conditions after pesticide application.

The pilot scale experiments show that the malathion content was decreased to a significantly lower level by the thorough water wash than it was by the less thorough wash, in contrast with DDT, where it was shown that thoroughness of the wash made relatively little difference in the amount of DDT removed. The use of a detergent resulted in significantly less removal of malathion in both washing treatments used.

The malathion found in peels and in waste from juicing operations shows that malathion remaining after washing is largely concentrated in these portions of the tomato. Similar results were obtained with DDT. These results indicate both malathion and DDT are preferentially held by waxes present in the tomato skins. In the tomatoes given a minimum wash, considerably more malathion was found in skins and waste when a detergent was used.

Unwashed tomatoes for home preparative studies contained an average of 6.3 p.p.m. malathion. A home-style cold water washing did not cause any significant change in the level of pesticide residue. This result is in contrast to the results of commercial washing experiments in which more than 80% of the malathion residue was removed. Immersion peeling by scalding in boiling water for one-half minute resulted in a significant 94% decrease in residue content. This observation is in agreement with commercial results. Waste trim from scald peeling contained 6.6 p.p.m. of malathion. Cold water peeling and quartering for stewing resulted in a 96% decrease of malathion in the fruit, while the discarded waste contained an average of 24 p.p.m. The majority of the malathion residue is, therefore, present in the tomato skin. In both the home preparative and commercial samples, the fruit itself contained very little pesticide.

Carbaryl Removal. The unwashed tomatoes utilized in the commercial processing experiment contained an average of 5.2 p.p.m. of carbaryl (Table VII). From 82 to more than 99% of this residue was removed by washing, the amount removed being dependent on the efficiency of the washing treatment. Differences between each of the four washing treatments were statistically significant. The minimum wash in cold water removed 82% of the carbaryl; in cold water with detergent, 96% of the carbaryl. The maximum warm water wash without detergent removed 97%, and the warm water wash with detergent removed more than 99% of the carbaryl residue. The detergent improved the removal in both the maximum and minimum wash conditions.

Removal of peels by steam peeling or by screening in the manufacture of tomato juice removed all but a negligible amount of residue and obscured differences between the washing procedures. Slightly more residue was found in the processed tomato juice than in the whole peeled to-

Table VII. Removal of Carbaryl from Tomatoes by Commercial Processing Procedures

Treatment	Total Solids	Average	Confidence Limits	% Decrease Wet	% Decrease Dry
Unwashed	4.59	5.2	1.14		
Washed					
W 1	4.59	0.91	0.53	83	82
W 1 D	4.62	0.23	0.05	96	96
W 2	4.81	0.14	0.07	97	97
W 2 D	4.64	tr.		99+	99+
Canned whole					
W 1	5.51	tr.		99+	99+
W 1 D	4.74	0.07	0.04	99	98
Canned juice					
W 1	5.41	0.11	0.03	98	98
W 1 D	5.35	0.11	0.02	98	98
W 2	5.25	0.11	0.03	98	98
W 2 D	5.60	0.11	0.02	98	98

W 1 = Minimum wash.
W 1 D = Minimum wash with detergent.
W 2 = Maximum wash.
W 2 D = Maximum wash with detergent.

nd = Not detected.
tr. = Trace, less than 0.05—value used for averages 0.03.

Table VIII. Removal of Carbaryl Residues from Tomatoes by Home Preparative Procedures

Treatment	Total Solids	Average	Confidence Limits	% Decrease Wet
Unwashed	5.34	8.4	3.2	
Washed	5.29	1.9	0.34	77
Peeled		0.71	0.38	92
Peels (waste)		4.2		
Canned (whole)		0.65		92
Canned (juice)		1.9		77
Stewed		2.6	0.30	69

matoes, but differences at this level of concentration cannot be considered significant. There is no apparent buildup of residue in tomato skins and in waste pulp from juicing operations as was observed with DDT and malathion. Carbaryl residues in these waste materials were less than 0.2 p.p.m. in most instances.

The unwashed tomatoes contained an average of 8.4 p.p.m. of carbaryl 1 day after harvest (Table VIII). A home-style cold water wash was only slightly less effective in removing carbaryl residues than commercial washing procedures. Peeling the tomatoes by immersion in boiling water removed 92% of the residue. Evidently, considerable amounts of carbaryl were removed by the hot dip, as shown by the relatively low concentration of carbaryl in peelings. Home canned peeled tomatoes contained carbaryl in about the same quantities as present in raw peeled tomatoes. There was a significant difference in carbaryl content between home canned whole tomatoes and home canned juice, the juice being higher in residue since the peels were not removed prior to the juicing operation. These values are somewhat higher than those obtained on comparable commercial samples because kitchen washing procedures are less effective in removing carbaryl. Since the tomatoes for stewing were peeled and quartered by hand without a hot water dip, a procedure less effective in removing residue, the stewed tomatoes contained 2.6 p.p.m. of carbaryl. A loss of moisture from the stewed tomatoes would account for a portion of this apparent increase. Since no hot water was used in peeling tomatoes for stewing, the concentration of carbaryl is considerably higher in the waste material than in waste material from tomatoes peeled by scalding.

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