Fate of Di-syston {*O,O*-Diethyl *S*-[2-(Ethylthio)ethyl] Phosphorodithioate} in Potatoes during Processing

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Total residues of Di-syston {*O,O*-diethyl *S*-[2-(ethylthio)ethyl] phosphorodithioate} were reduced by 35% with lye peeling. Lye peeling plus the first water blanching reduced the total residue on a dry weight basis by 58, 74, and 61% for french fries, dehydrated cubes, and dehydrated mashed, respectively. When expressed on a dry weight basis, dehydration caused a further reduction in total residue. Apparent increases in oil cooking french fries were attributed to a dehydration effect. On a dry weight basis overall reduction in residues due to processing potatoes into french fries, dehydrated cubes, dehydrated mashed, and chips were 77, 91, 89, and 97%, respectively.

Liska and Stadelman (1969) and Farrow *et al.* (1969) have recently reviewed the effects of commercial preparations on pesticides in foods. The effect of processing on DDT, malathion, and carbaryl residues in tomatoes was studied by Farrow *et al.* (1968). Malathion residues were reduced by more than 99% in commercial processing procedures for whole tomatoes and canned juice. Koivistoinen *et al.* (1964) studied the effect of processing and storage on malathion residues in six different types of plant products. Residues were reduced 30 to 90%, depending upon the processing procedure. Farrow *et al.* (1969) reported that canning processes reduced residues of malathion by more than 90%. Parathion reduction was 66% during the canning processes but only 10% in processes utilized for preparing frozen broccoli. Lamb *et al.* (1968), working with potatoes, found a 94% decrease in DDT residues from washing plus lye peeling.

Nonsystemic insecticide residues in food are deposited on the surface and large quantities can be removed by washing and peeling processes. Since systemic insecticide residues are not necessarily concentrated at the surface, their fate during processing procedures may vary from the nonsystemic residues. Little is known about the fate of the systemic insecticide Di-syston during processing. This investigation was carried out to determine the fate of Di-syston in potatoes during several processes.

MATERIALS AND METHODS

Reagents. Analytical grade Di-syston and its oxygen analog sulfone were supplied by Chemagro Corp., St. Louis, Mo. All solvents were analytical reagent grade and purified by redistilling in an all-glass apparatus. All other chemicals were analytical reagent grade.

Plant Material. Potatoes (*Solanum tuberosum* var. Russet Burbank) were grown at the Washington State University Experiment Station, Othello, Wash. Potatoes were treated by banding triple 16 fertilizer impregnated with 1% Di-syston slightly above and about 2 in. on each side of the seed piece at planting time. The total Di-syston application was 12 lb per acre, which is in excess of registered dosage. Potatoes were harvested on Oct 30 and placed in storage for 20 days before processing.

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Processing. Processing was done in the pilot plant laboratory of Ernest Todd, Chef Reddy Foods, Othello, Wash. Approximately 300 lb of potatoes were peeled in a commercial lye peeler. The peeler contained 16.7% sodium hydroxide solution maintained at 77° C. The potatoes were in the peeler 2.5 min.

French fries were made by slicing the peeled potatoes into $^3/_8$-in. × $^3/_8$-in. strips and water blanching for 9 min at 67° C, followed by an additional blanch for 3 min at 88° C. The blanched potatoes were cooked in oil for 55 sec at 192° C and quick frozen at −30° C. The frozen french fries were cooked in oil at 192° C for 2 min.

Dehydrated cubes were prepared by dicing the peeled potatoes into pieces $^1/_4$-in. × $^3/_8$-in. × $^1/_2$-in. The cubes were water blanched for 9 min at 67° C followed by an additional water blanch of 3 min at 88° C. The blanched cubes were immersed in a 1% sodium bisulfite solution at room temperature for 15 sec. The bisulfite-treated cubes were transferred to plastic trays and dehydrated in a forced air drying oven for 3 hr at 88° C, followed by an additional 3 hr at 54° C.

Dehydrated mashed potatoes were made by slicing the peeled potatoes $^3/_8$-in. thick and water blanching for 20 min at 67° C. The blanched slices were water quenched for 20 min at room temperature and steam cooked for 25 min. The steam cooked potatoes were mashed and dehydrated for 2 hr at 78° C, followed by an additional 5 hr at 65° C.

Potato chips were made from 0.058-in. slices which were cooked in oil at 190° C until dryness.

Samples (200 g) were taken from each step of the processing procedures, immediately frozen, and stored until analysis.

Analysis. Determinations of Di-syston and its active metabolites were made by the method of Thornton and Anderson (1968). This procedure oxidizes the Di-syston and its oxygen analog to their corresponding sulfones which are determined separately by gas chromatographic analysis. Water was added back to dehydrated samples before acetone extraction.

Gas–liquid chromatographic analysis was made on a Varian Aerograph Model 204 equipped with an alkali flame detector. Di-syston sulfone and its oxygen analog sulfone were separated on a $^1/_8$-in. × 5-ft glass column packed with 5% OV-101 on $^{60}/_{80}$ mesh Gas Chrom Q. The injection port, detector, and column were maintained at 225, 270, and 200° C, respectively. Hydrogen, nitrogen, and air flow rates were 17, 25, and 170 ml/min. At the operating conditions employed, the retention time for the Di-syston sulfone

Table I. Fate of Di-syston and its Oxygen Analog During Processing[a]

Process	Di-syston ppm, wet wt	O_2 Analog ppm, wet wt	Total ppm, wet wt	Moisture %	Total ppm, dry wt	Cumulative reduction %
Whole potato	0.59 ± 0.02	0.74 ± 0.02	1.33	79.0	6.35	
Lye peeled potato	0.29 ± 0.01	0.57 ± 0.03	0.86	78.9	4.09	35.4
French fry						
H_2O Blanch 9 min @ 67° C	0.20 ± 0.01	0.33 ± 0.04	0.52	80.4	2.66	58.2
H_2O Blanch 3 min @ 88° C	0.13 ± 0.02	0.22 ± 0.02	0.35	80.1	1.75	72.5
Oil cook 55 sec @ 192° C	0.24 ± 0.01	0.37 ± 0.05	0.61	68.6	1.55	75.6
Oil cook 2 min @ 192° C	0.30 ± 0.01	0.52 ± 0.04	0.82	49.8	1.46	77.1
Dehydrated cubes						
H_2O Blanch 9 min @ 67° C	0.11 ± 0.01	0.22 ± 0.02	0.33	80.2	1.68	73.6
H_2O Blanch 3 min @ 88° C	0.09 ± 0.01	0.16 ± 0.01	0.24	81.2	1.29	79.7
Dehydrate	0.21 ± 0.01	0.34 ± 0.02	0.55	8.6	0.60	90.6
Dehydrated mashed						
H_2O Blanch 20 min @ 67° C	0.18 ± 0.04	0.38 ± 0.05	0.56	77.4	2.48	61.0
H_2O Quench 20 min @ Rm Temp	0.16 ± 0.01	0.28 ± 0.02	0.44	78.2	2.00	68.6
Steam cook 25 min	0.08 ± 0.01	0.13 ± 0.01	0.21	79.3	0.98	84.6
Dehydrate	0.25 ± 0.02	0.44 ± 0.04	0.69	4.1	0.72	88.7
Chip						
Oil cook 192° C to dryness	0.06 ± 0.01	0.15 ± 0.01	0.21	1.3	0.21	96.7

[a] Samples were taken after each successive step during processing; therefore, the reduction in residues in cumulative for all steps through the one listed under each process. Values represent averages from at least two separate samples.

was 1.8 min and the oxygen analog sulfone was 1.5 min. The residues were calculated as ppm of Di-syston.

RESULTS AND DISCUSSION

Table I shows the fate of Di-syston and its oxygen analog during processing procedures common in the potato processing industry. The raw potato contained 0.59 ppm of Di-syston and 0.74 ppm of oxygen analog for a total residue of 1.33 ppm on a wet weight basis and 6.35 ppm on a dry weight basis. A 35% reduction in the total residue is realized as a result of lye peeling the potato. Lye peeling reduces more Di-syston residue than its oxygen analog. This indicates that the relative amount of oxygen analog to Di-syston is less in the peel than in the rest of the potato.

Lye peeling plus a single water blanching of the strips (french fries), dice (dehydrated cubes), and slices (dehydrated mashed) reduces the total residues from 58 to 74%. An additional blanching of the strips and dice further reduces the residues. Water quenching and steam cooking the slices also reduces the total residue. The water solubility of Di-syston is approximately 25 ppm and therefore it is not surprising that water blanching significantly reduces residue levels. Degradation of the residues during blanching may play a role in the reduction of total residues.

The effect of cooking french fries in oil is essentially dehydration causing an apparent increase in the residue levels. When the residues are expressed on a dry weight basis, it is evident that very little residue is lost from the french fries during oil cooking. Considering the solubility of Di-syston in oil, one might expect appreciable amounts of the residue to be extracted. Perhaps the water blanching process efficiently reduces the residues on the outer portions of the strips and the oil cooking does not eliminate residues any deeper than the blanching process.

Dehydration of the cubes and mashed potatoes caused apparent increases in the residues when expressed on a wet weight basis. However, when expressed on a dry weight basis, there is a reduction in the total residue.

Oil cooking the 0.058-in. slices to dryness for chips reduced the total residues to 0.21 ppm. Oil cooking these slices was more effective in removing the total residues than in the french fries because the slices were thin, they had not previously been water blanched, and they were cooked to dryness. Degradation of the Di-syston by the high temperatures used could also contribute to the reduction in the residues.

Analysis of the blancher solutions after processing indicated that a large amount of the Di-syston lost from the potatoes during blanching was leached into the blancher solution.

In all cases the absolute amount of Di-syston residues in the raw potato was significantly reduced during processing potatoes into french fries, dehydrated mashed, dehydrated cubes, and chips.

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