Bull. Environ. Contam. Toxicol. (2003) 70:213–218

DOI: 10.1007/s00128-002-0179-2

Bulletin of Environmental Contamination and Toxicology

Reduction of Pesticide Residues of Fruit Using Water Only or Plus Fit™ Fruit and Vegetable Wash

R. I. Krieger, P. Brutsche-Keiper, H. R. Crosby, A. D. Krieger

Personal Chemical Exposure Program, Department of Entomology, University of California, Riverside, CA 92521, USA

Received: 30 April 2002/Accepted: 19 August 2002

Responsibility for regulating the food supply and pesticide residues in the United States rests with the Environmental Protection Agency (USEPA), the Food and Drug Administration (FDA), and the Department of Agriculture (USDA). Earliest concerns about residues resulted from use of arsenical pesticides, sometimes visibly deposited on apples and pears, which posed an acute toxicity hazard to consumers. Regulatory activities during the past century concerning chemicals in food have changed dramatically. Surveillance and compliance monitoring by the U. S. Food and Drug Administration Pesticide Program (NTIS) and similar programs of some states have documented the occurrence of trace chemical residues in foods in the past. In more recent times in a continuing quest for "pure food" (Carnevale et al., 1991), researchers have accumulated considerable data concerning consumers, the persons least exposed to pesticides. In the current era, the Food Quality Protection Act of 1996 (FQPA) has called for major change and for aggregation of trace residues on food with those from air, water, and non-dietary sources. FQPA recasts pesticide exposures from treated fruit and produce as a hypothetical threat to health. The new law and advertising claims about pesticide residue reduction on foods have captured the anxiety of some consumers already apprehensive about food safety. Products alleged by advertisers to reduce fruit and produce pesticide residues more effectively than water are touted to concerned consumers. Their opinions are often not impacted by the availability of pesticide residue monitoring data that consistently document the wholesomeness of the food supply.

Procter & Gamble's Fit® Fruit & Vegetable Wash has been an especially prominent example of these pesticide-reducing products. "Fit® Fruit & Vegetable Wash labels proclaim the product proven to be "98% more effective than water at removing pesticides most commonly found on produce." Product information titled "Overview of Produce Wash Efficacy" offers no details about the amounts of 10 pesticides removed from fruits and vegetables "representative of 80% of produce consumed in the United States" (Procter & Gamble, 2000). The claim "98% more effective than water" seems unlikely given the effectiveness of water and misleads a public already wary of pesticide and food safety issues.

Following normal pesticide use in integrated pest management (IPM), to protect

Correspondence to: R. I. Krieger

produce pesticide residues that remain at harvest are well below levels that might adversely affect the health of either laboratory rats or humans. This paper reports the effectiveness of water and water plus Procter & Gamble's Fit® Fruit & Vegetable Wash for removal of captan, a surface-active fungicide, and methomyl, a relatively more water soluble, N-methyl carbamate insecticide, from fruit.

MATERIALS AND METHODS

Captan (Part 1) or captan and methomyl (Part 2) sprays had been applied under normal conditions to a field crop on the south central coast of California. Samples from channels of trade were obtained at a regional distribution center. The crop used in these studies is not reported since it is not material to relative measurements of residue reduction. Tap water and tap water plus Fit® Fruit & Vegetable Wash were used to wash fruit. Fit® contains water, oleic acid, glycerol, ethyl alcohol, potassium hydrate (KOH), sodium carbonate, citric acid, and grapefruit oil.

In Part 1 captan treated fruit was transported in insulated coolers to the laboratory in Riverside, CA. Study participants ("homemakers") were blinded to the goals and objectives of the work. Shelf packs of fruit (40 lots) were distributed to 10 consumers who prepared the fruit using their customary procedures. Lot 1 was prepared using a water rinse and a second lot was prepared using water plus Fit® Fruit & Vegetable Wash. Lot 3 was unrinsed but transported and handled like the others. Each homemaker received an additional lot of fruit as a token of appreciation. The ready to serve fruit was transferred in zip-lock bags, refrigerated on wet ice, and transported to a commercial pesticide residue laboratory for residue analysis (Primus Laboratories, Santa Maria, CA).

In Part 2 fruit had been treated in the field with a tank mix of captan and methomyl several days before harvest. Shelf packs of fruit (30 lots) were randomly designated as either controls or rinsed with tap water or tap water plus Fit® Fruit & Vegetable Wash as indicated on the label. Two homemakers and a teenaged assistant prepared the fruit in a large motel kitchenette. Conditions simulated fruit preparation by a typical homemaker. All kitchen gear was thoroughly rinsed with water and a bottlebrush after processing each batch of fruit as described in the next paragraph.

Fruit was placed into a Fit® Washing Kit colander. Two liters of water only or water plus a capful (58 ml) of Fit® Fruit & Vegetable Wash were put into the Fit® Washing Kit bowl. The fruit was soaked in the bowl for 30 seconds and then was gently rinsed for four successive 30-second intervals. The fruit was then rinsed for 5 seconds in 2L of fresh tap water. The fruit was drained on paper towels, bagged and labeled, and refrigerated (wet ice) before transport to the laboratory.

Fruits (unrinsed controls, water rinsed, and water + Fit®) were analyzed using

Table 1. Captan and methomyl residue reduction by water only and water plus Procter & Gamble's Fit® Fruit and Vegetable Wash.

Product	Captan		Methomyl	
	Parts per Million	Residue Reduction	Parts per Million	Residue Reduction
Study 1 (n= 10)				
Unrinsed	6.7	--	--	--
Water only	4.1	39%	--	--
Water + Fit®	3.7	45%	--	--
Study 2 (n= 10)				
Unrinsed	0.52	--	0.87	--
Water only	0.10	81%	0.71	18%
Water + Fit®	0.053	90%	0.53	39%

Food and Drug Administration Pesticide Analytical Manual (FDA 1994) residue methods (PAM 242.1) at Primus Laboratories. Coded samples were supplied to the analysts who were blinded to the rinsing scheme and the objectives of the study. Results were reported as ug pesticide/g fruit (ppm).

The pesticide residue reduction (RR) factor representing residue reduction and surface pesticide residue was calculated as follows:

$$RR = 100 - [(\text{residue of rinsed fruit} / \text{residue of unrinsed fruit}) \times 100]$$

An ANOVA was run for each part. In all three completely randomized designs, the treatments being compared are the pesticide residue in parts per million of unwashed fruit (control), fruit washed with water, and fruit washed with water plus Fit® Fruit & Vegetable Wash. Tukey's multiple comparison procedure was used to discover the exact nature of the differences among the three treatments.

RESULTS AND DISCUSSION

All captan and methomyl residues were below U. S. EPA tolerances. The captan residues in the two parts of this work differed by an order of magnitude probably due to agronomic factors including application equipment, captan application rate, general field conditions, and pre-harvest intervals.

Captan residues were reduced up to 81% when fruit was rinsed with water only and up to 90% when rinsed with water plus Procter & Gamble's Fit® Fruit & Vegetable Wash. Part 1 involved 10 homemakers and 4 lots of fruit treated in the field with captan. The fruit an average 6.7 ppm captan (Table 1). The fruit rinsed with only water by homemakers contained 4.1 ppm captan and fruit rinsed with water plus Fit® contained 3.7 ppm captan. The residue reduction factors that represent the surface captan residue were 39% and 42%, respectively (Table 1).

Table 2. Claimed residue removed by rinses are greater than total residue present on fruit.

Fruit Rinse	Measured			Hypothetical	
	Total Captan Residue	Residue Removed By Water	Claimed Residue Removal By Rinse: *"...than water"*	Calculated Residue (ppm)	Per Cent of Total Captan Residue on Fruit
	1	2	3	4 = 2 x 3	5 = (4/1) x 100
Water	0.52 ppm	0.42 ppm	-	-	-
Fit® Fruit And Vegetable Wash			*98% more*	0.83	160%
Veggie Wash®			*300% more*	1.3	250%
Environné® Fruit & Vegetable Wash			*400% better*	1.7	327%
Fresh Wash®			*5 times more*	2.1	404%
Harvest Wash®			*10 times more*	4.2	808%

Each rinse significantly lowered the captan residue compared to residue from unrinsed fruit ($p=0.0004$ for water only; $p= 0.0001$ for water plus Fit®). The remaining residues were not significantly different ($p=0.78$) whether water only or water plus Fit® were used.

The mean residues for control, water-rinsed fruit, and water plus Fit® Fruit & Vegetable Wash rinsed fruit are different. The ANOVA F-test had a p-values of $p<0.001$. Each rinse significantly ($p<0.05$) lowered the captan residue. The residues were not significantly different whether the fruit had been rinsed with water only or Fit® Fruit & Vegetable Wash.

Fruit treated in the field with a captan and methomyl tank mix was used in Part 2 of this residue reduction study. The results are given in Table 1. Low levels of captan and methomyl residue were present on unwashed fruit. Lot 1 was water rinsed and lot 2 was rinsed with water containing Fit® Fruit & Vegetable Wash. The percentage of the captan residue removed was greater than the percentage methomyl residue removed. The ANOVA F-tests for captan and methomyl had p-values of $p<0.001$ and $p=0.003$, respectively. The captan residues of controls and water rinsed fruit were significantly different ($p<0.0001$). Similarly, the

captan residues of controls versus water plus Fit® were significantly different ($p<0.0001$). However, the captan residues of the water rinsed fruit versus water plus Fit® were not significantly different ($p=0.77$). The methomyl residues of controls and water rinsed fruit were not significantly different ($p=0.21$). Similarly, the methomyl residues of water rinsed versus water plus Fit® were not significantly different ($p=0.12$). The water plus Fit® rinse reduced the methomyl residue compared to the unrinsed controls ($p=0.0022$). The surface nature of the captan residue makes it more available to the rinses than methomyl.

In each case, water-containing Fit® removed more methomyl residue, but a smaller percentage of the total residue than water only. The penetrated residue was 82% of the total methomyl residue, but the penetrated captan residue was only 19% of the total. Fit® Fruit & Vegetable Wash approximately doubled the methomyl residue removed by water only. Plant waxes are removed by Fit® Fruit & Vegetable Wash (2000). Ingredients of Fit® including ethanol may remove more methomyl that has penetrated cuticular waxes than water only. The additional amounts of pesticide residue removed by Fit® Fruit & Vegetable Wash are of analytical significance. Whether the fruit was unrinsed, rinsed with tap water, or rinsed using Fit® Fruit & Vegetable Wash all fruit residues were within food tolerances established by the U. S. Environmental Protection Agency and far below levels that could cause an adverse health effect in rats or humans. These studies reaffirm the effectiveness of water for trace pesticide residue reduction on produce. Additional factors including the nature of the water wash/rinse, characteristics of the produce surface, spray adjuvant, and post-application time may also influence the fate of trace pesticide residues during normal rinsing. A World Health Organization summary (2000) reports that water only reduces captan residues on cucumber (80%), cherries (70%), peaches (60%), and apples (50%). Methomyl residues of lettuce (90%), green beans (washed and trimmed 50%), apples (30%), and peaches (80%) are substantially reduced by a water rinses only (Devine, Personal communication). Lipophilic pesticides penetrate hydrophobic plant surfaces to varying extents based upon the nature of both the pesticide and the plant. Captan was removed to a greater extent than methomyl. Residues not fully removed by water rinses are probably contained within the cuticle and flesh of the fruit.

The claim that Procter & Gamble's Fit® Fruit & Vegetable Wash, "Removes 98% more chemicals and wax than water alone!" is not supported by the results of either the captan or methomyl residue removal studies. In the case of methomyl, the amount of residue remaining was not significantly different with either rinse, but the residue following water plus Fit® was lower than that of the unrinsed controls. Typical consumer food preparation (Table 1) and controlled laboratory studies (Table 2) each revealed the invalidity of the advertising. In no case were residues of health significance. It is likely that many other pesticide residues, especially unpenetrated or surface ones, would produce similar results. Similar unsupportable claims have been made for other produce washes. Envirronné/Consumer Health Research, Inc. (www.vegiwash.com) states,

"Independent laboratory tests have shown Envirronné Fruit & Vegetable Wash® has not only removed up to 97% of these surface residues, but works 400% better than water alone." Fresh Wash® (www.sneakykitchen.com/watkins) is touted to remove "over 90% of surface contaminants—up to 5 times more than plain water." The Harvest Wash (www.tnplh.com/harvest.html) claim is more extreme: "University testing has proven that Harvest Wash®, when used as a rinse agent, cleans produce of surface contaminants 10 times more efficiently than water alone!" Due to the effectiveness of water only to remove surface residue, there isn't sufficient pesticide residue remaining to support these claims (Table 2).

In summary, captan and methomyl residues were below food tolerances whether the produce was unwashed, or washed with water only, or water containing Procter & Gamble's Fit® Fruit & Vegetable Wash. The claim that there would be 98% more pesticide residue reduction than with water only was not statistically significant for either methomyl or captan. Water only and water plus Fit® removed 39% and 45% of a 6.7 ppm captan residue and 81% and 90% of a 0.52 ppm residue (Table 1). Methomyl residues of 0.87 ppm on unwashed produce were reduced 18% and 39% by the rinses, but the difference was not significant.

The effectiveness of a water rinse to remove trace surface residues invalidates the claims for Fit® Fruit & Vegetable Wash and other similarly advertised products. Other extreme advertising claims for produce rinses and/or washes (Table 2) are also unjustified since water only substantially reduces trace pesticide residues. In the examples taken from this study, to satisfy the claimed residue reductions, the four additional products would have to remove up to 808% of the total residue present on unwashed fruit.

Acknowledgement. Cooperating farmers, homemakers, and the assistance William Krieger were essential to the conduct of this work.

REFERENCES

Carnevale, R A, W A Johnson, C A Reed and A Post (1991) Agricultural chemical residues in food: Evaluating the risks. Agriculture and the Environment. The 1991 Yearbook of Agriculture (U. S. Govt. Printing Office 1991 0-297-291 QL 2) pp 227-233.

Devine, P.G. (2002). Magnitude of residues of methomyl. E.I. du Pont de Nemours and Company DuPont Agricultural Products (Wilmington, Delaware, USA) Personal communication.

Food and Drug Administration (FDA;1994) Pesticide Analytical Manual (3rd Edition), V. 1, Method 302-E1. p 302-5-6.

Procter & Gamble (2000) Fit® Fruit & Vegetable Wash. Overview of Produce Wash Efficacy. (Cincinnati, Ohio, USA; 4/20/2000) 3 pp.

World Health Organization (2000) Pesticide residues in food-2000. FAO Plant Production and Protection Paper 165 (Geneva, Switzerland). p. 102.