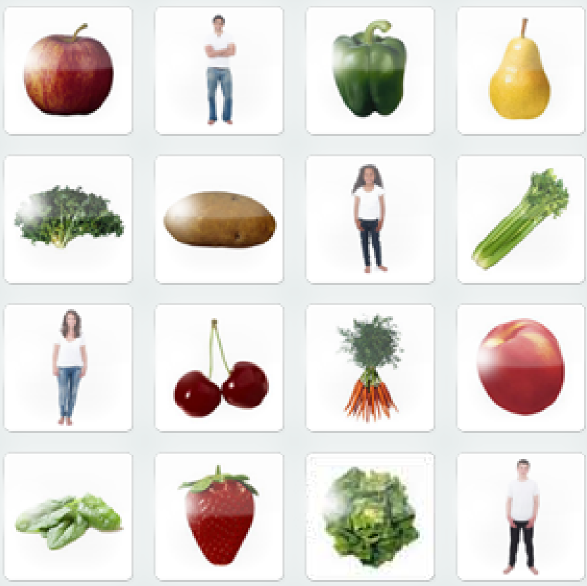
PERSPECTIVE ON PESTICIDE RESIDUES IN FRUITS AND VEGETABLES



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PESTS AND OUR FRUITS AND VEGETABLES

Farmers who choose to provide fruits and vegetables to increasingly large numbers of consumers recognize particular insects, mites, weeds, nematodes, disease-causing organisms, and vertebrates as competitors that may lower the quality and yield of their produce. Managing pests for crop protection has been a continual challenge wherever agriculture has been practiced. The ageless competition between insects and humans was described by Forbes in an Illinois State Laboratory Bulletin in 1915 as follows:

> "The struggle between man and insects began long before the dawn of civilization, has continued without cessation to the present time, and will continue, no doubt, as long as the human race endures. It is due to the fact that both men and certain insect species constantly want the same things at the same time. Its intensity owing to the vital importance to both, of the things they struggle for, and its long continuance is due to the fact that the contestants are so equally matched. We commonly think of ourselves as the lords and conquerors of nature, but insects had thoroughly mastered the world and taken full possession of it long before man began the attempt."

The widespread introduction of synthetic organic pesticides into crop protection in the 1940s allowed reduction of pest abundance and pest damage to levels that were not previously possible. Plant breeding, fertilization, irrigation, and pesticide technologies are characteristics of the world's most productive agriculture in spite of the continuing presence of pests. Since 1900 Americans spend 50% less of their income to feed themselves (Food Marketing Institute 1994). A National Academy of Sciences estimate (NRC 1991) of disposable income of a typical American family indicated that approximately 10% is used to purchase food, lower than any other country (CAST 1992). These data prompt the suggestion that a major benefit of pesticide use is an abundant supply of nutritious produce.

Pests do not distinguish whether fruits and vegetables are produced in conventional or organic agriculture. When pests threaten the farmer's ability to market produce for profit, pesticides may be a means to protect the food for human consumption.

PESTICIDE REGULATION IN CROP PROTECTION

All aspects of pesticide use in modern agriculture are highly regulated. That doesn't make the process perfect, but pesticide regulation is a very transparent process to both scientists and the public. The first pesticide registration laws in 1910 were primarily aimed at protecting consumers from ineffective products and deceptive labeling. The laws regulating pesticide use are based upon two laws. In 1938 the Federal Food, Drug and Cosmetic Act (FFDCA) that enabled enforcement of tolerances was passed. The Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) was first passed in 1947. It established procedures for registering pesticides with the U.S. Department of Agriculture and established labeling provisions and tolerances.

FIFRA was rewritten in 1972 when it was amended by the Federal Environmental Pesticide Control Act (FEPCA). The law has been amended numerous times since 1972, including some significant amendments in the form of the Food Quality Protection Act (FQPA) of 1996.

PESTICIDE SAFETY EVALUATION AND RISK CHARACTERIZATION

Toxicologists conduct carefully designed and controlled studies to reveal the nature and extent of potential toxic effects of pesticides in humans. Hazard Identification or safety evaluation studies reveal the inherent toxicological properties of chemicals. Further characterization of qualitative and quantitative responses to the pesticide is defined by Dose-Response Relationships. Safety evaluation studies are guided by the fundamental tenet of toxicology that there is a dose level for any chemical that will not produce a response.

The importance of a threshold "no effect level" of exposure is explicitly described by Health Canada (2008) as follows: "Most responses elicited by a substance, including acute toxicity, chronic toxicity, neurotoxicity, irritation, developmental toxicity, and reproductive toxicity are considered threshold in nature. Endpoints [Responses] that have been observed to lack a threshold response (e.g. genetic toxicity, carcinogenicity) are assumed to result in an increase in risk at any level of exposure and hence are subject to different risk assessment methodologies."

The experimental dose level at which no adverse effects are observed is the No Observed Adverse Effect Level (NOAEL; mg chemical/kg body weight laboratory animal). The lowest dose at which adverse effects were observed in a particular study is the LOAEL. An adverse effect is "a change in morphology, physiology, growth, development, or lifespan of an organism which results in impairment of functional capacity to compensate for additional stress or increase in susceptibility to the harmful influences of other environmental influences (International Programme on Chemical Safety, 1994)."

Evaluation of the toxicological database for a particular pesticide will identify NOAELs associated with different tests. NOAELs associated with short-term (acute) dietary exposures related to the potential consumption of fruits and vegetables containing pesticide residues are used in the comparative data reported here.

PESTICIDE RESIDUE TOLERANCES

Before EPA can register a pesticide for crop protection, it must grant a tolerance. A tolerance is the maximum amount of a pesticide that can be on a raw product when it is used and still be considered safe. Tolerances are based upon use of the pesticide product in accord with good agricultural practices. Tolerances are established under conditions that maximize the potential for residues. Controlled field trials use the maximum rate permitted on the label, the maximum number of applications, and the minimum pre-harvest interval (the number of days between the last application and harvest). The FFDCA requires EPA to establish these residue tolerances based upon the specific uses of a pesticide product.

The 1996 FQPA amended the FIFRA and the FFDCA. Among other changes, FQPA established a health-based standard ("a reasonable certainty of no harm") for pesticide residues in food to assure protection from unacceptable pesticide exposures. Actual crop residues of registered pesticides are almost always well below established tolerances, exceptions representing trace residues resulting from drift, carry-over soil residues from previous applications, or rarely illegal pesticide use.

PESTICIDE DATA PROGRAM OF THE U.S. DEPARTMENT OF AGRICULTURE

Fruits and vegetables that are marketed following use of pesticides in conventional or organic crop protection may contain trace levels of residues. The amounts are too small to be listed among Food Facts on ingredient labels, but many can be measured by sensitive analytical procedures available in regulatory, university, and industry laboratories. By law, they must be less than tolerances and, in practice, pesticide residues are usually much less than that regulatory standard.

In 1991, the United States Department of Agriculture (USDA) was charged with designing and implementing a program to collect data on pesticide residues in food. Responsibility for this program was given to the USDA Agricultural Marketing Service (AMS), which began operating the Pesticide Data Program (PDP) in May 1991. The data produced by PDP are reported in an annual summary. Those measurements can be used to estimate consumer exposure and the relationship of those exposures to science-based standards of safety. The reasonable certainty of no harm to human health can be applied to any of the trace pesticide residues in produce.

EWG SHOPPER'S GUIDE DOESN'T DELIVER

While completely safe for consumption, the levels of pesticide residues are confusing to consumers and are often misconstrued by organizations such as Environment Working Group (EWG). They take these low levels of pesticide and equate presence of residues with risk and completely disregard the science behind the policies that allow these levels on produce. Using a method devised by the organization themselves, EWG has come up with a dirty dozen list, which purports to show the 12 commodities that show the most pesticides and are not safe for consumption and a clean 15 list, which have the least pesticide residues and the consumers should use as alternative. They strongly encourage consumers to only eat organic food. The method used by the organization does not make sense as some are redundant, and have no scientific base. Using the data published in the PDP, for each commodity, they take the percent of samples tested with detectable pesticide, percent of samples with 2 or more pesticides, average number of pesticides found on a sample, average amount of all pesticide found, maximum number of pesticides, and the total number of pesticides found on commodity and add all these values up. It's obvious that this can not be used to estimate exposure. The net result only serves to alarm the consuming public and doesn't tell anything about what they are consuming.

As the residue levels on the commodities are confusing to the consumers and can easily create a scare, this paper aims to give consumers a better reference related to serving sizes. This information would make clear how safe the pesticide residues are based on dosage but relatable to them.

OUR METHODOLOGY

Commodities on the dirty dozen list, clean fifteen list, and select others were used. Since EWG mainly used levels to determine "dirty" or "clean", we took the highest level of the pesticide reported in the PDP to do our analysis. To calculate the extent of exposure required to achieve the NOAEL, we created an algorithm that takes in account the full serving size of the commodity, the NOAEL for the pesticide, and average body weight. Since consumption varies with ages, four groups were created based on the average body weight of children, teen, women, and men. The consumer specific body weights are based on the reference standards used by the USEPA. The Dietary NOAEL for each pesticide was acquired from EPA and the average serving size used are as determined by FDA.

The algorithm used was:

Equivalent Servings = NOAEL (mg/kg) x Body Weight (kg) x 1000/ residue (ppm) x serving size (g)

DISCUSSION

Our calculations show that consumption of hundreds to thousands of average servings are required to represent even the no effect levels of pesticide exposure at the very highest residues measured for each pesticide in each crop. While mainly having higher serving sizes, some of the serving size of commodities on the clean 15 lists are less than the commodities on the dirty dozen list. This shows the consumers that the amount of residue is not a good estimate of risk. Each pesticide has its own NOAEL level based on its dose-response curve in animals. Until the NOAEL is applied to the amount of residue present, reporting the amount present on the commodities is not useful to evaluate risk.

CONCLUSION:

Shoppers are urged to take a careful look at the EWG classification scheme. It is determined by the number of residues (not amount) occurring in produce in the USDA Pesticide Data Program samples. EWG and uncritical media transform the EWG numbers into a notion of potential consumer exposure. No Effect levels of pesticide exposure can be assigned to produce at any position in the EWG ranking system from number 1 to 49. It is groundless to suggest that the Shopper's Guide can be used to meaningfully predict risk. The testing that is used to identify the inherent hazards of pesticides also yields a measure of exposure that is not associated with any detectable adverse effects (toxicity). The pesticide exposures that result from consumption of hundreds to thousands of servings of produce with the very highest residues measured represent no effect levels of exposure.

Robert Krieger is an educator and a Fellow in The Academy of Toxicological Sciences who maintains an active research program concerning the fate of chemicals, particularly pesticides, in plants, animals and people. He holds a BS in chemistry from Pacific Lutheran University (1967) and a Ph D from Cornell University (1970) where he studied pesticide science, biochemistry, and physiology. Very interested in how people perceive chemicals as a threat to health and environmental quality. Research concerns methods and techniques to measure human pesticide exposures in residential and agricultural environments. He is currently the Director of the Personal Chemical Exposure Program, Department of Entomology, University of California, Riverside, where he is a Cooperative Extension Toxicologist.

Servings of Fruits and Vegetables Equivalent to a NOAEL Dose at the Highest Reported Residues, USDA: Pesticide Data Program

"DIRTY DOZEN"*

Commodity	Highest PDP Residue	Residue (ppm)	NOAEL Dose (mg/kg-bw/day)	Consumer	Body Weight (Kg)	Servings Eqivalent to the NOAEL
Apple	Diphenylamine (DPA)+	4.2	10	Child (2-5y)	20	340
				Teen(12-19)	40	680
				Woman	50	850
				Man	70	1190
Blueberries	Iprodione	2.7	100	Child (2-5y)	20	5291
				Teen(12-19)	40	10582
				Woman	50	13228
				Man	70	18519
Carrots	Linuron	0.65	20	Child (2-5y)	20	7240
				Teen(12-19)	40	14480
				Woman	50	18100
				Man	70	25339
Celery	Dicloran	1.5	50	Child (2-5y)	20	7843
				Teen(12-19)	40	15686
				Woman	50	19608
				Man	70	27451
Cherry	Tebuconazole	3	10	Child (2-5y)	20	476
				Teen(12-19)	40	952
				Woman	50	1190
				Man	70	1667
Cherry Tomatos	Flonicamid	2.3	3.7	Child (2-5y)	20	379
				Teen(12-19)	40	757
				Woman	50	946
				Man	70	1325
Cucumbers	Oxamyl oxime	1.7	0.1	Child (2-5y)	20	12
				Teen(12-19)	40	24
				Woman	50	30
				Man	70	42
Hot Peppers	Acephate	3.1	0.5	Child (2-5y)	20	108
				Teen(12-19)	40	215
				Woman	50	269
				Man	70	376
Kale/ Collard Greens	Permethrin	0.79	25	Child (2-5y)	20	7446
				Teen(12-19)	40	14892
				Woman	50	18615
				Man	70	26061
Lettuce (Conventional)	Propamocarb HCL	18	150	Child (2-5y)	20	1667
				Teen(12-19)	40	3333
				Woman	50	4167
				Man	70	5833
Lettuce (Organic)	Spinosad	0.4	2.68	Child (2-5y)	20	1340
				Teen(12-19)	40	2680
				Woman	50	3350
				Man	70	4690
Nectarine	Iprodione	6.2	100	Child (2-5y)	20	2304
				Teen(12-19)	40	4608
				Woman	50	5760
				Man	70	8065
Peaches	Iprodione	7.2	100	Child (2-5y)	20	1890
				Teen(12-19)	40	3779
				Woman	50	4724
				Man	70	6614
Pears	Diphenylamine (DPA)	5.6	2.5	Child (2-5y)	20	64
				Teen(12-19)	40	128
				Woman	50	159
				Man	70	223
Potato	Chlorpropham	23	250	Child (2-5y)	20	1469
				Teen(12-19)	40	2938
				Woman	50	3672
				Man	70	5141
Snap Peas	Acephate	2.6	0.5	Child (2-5y)	20	46
				Teen(12-19)	40	93
				Woman	50	116
				Man	70	162
Spinach	Permethrin	19	25	Child (2-5y)	20	310
				Teen(12-19)	40	619
				Woman	50	774
				Man	70	1084
Strawberry	Captan	7.5	10	Child (2-5y)	20	181
				Teen(12-19)	40	363
				Woman	50	454
				Man	70	635
Sweet Bell Pepper	Acephate	1.5	0.5	Child (2-5y)	20	78
				Teen(12-19)	40	157
				Woman	50	196
				Man	70	275

* EWG has included these commodities on current or past "dirty dozen" lists.

Servings of Fruits and Vegetables Equivalent to a NOAEL Dose at the Highest Reported Residues, USDA: Pesticide Data Program

"CLEAN 15"*

Commodity	Highest PDP Residue	Residue (ppm)	NOAEL Dose (mg/kg-bw/day)	Consumer	Body Weight (Kg)	Servings Eqivalent to the NOAEL
Asparagus	Carbofuran	0.075	0.22	Child	20	690
				Teen	40	1380
				Woman	50	1725
				Man	70	2416
Avocado	Imiprothrin (+)	0.2	5	Child	20	3571
				Teen	40	7143
				Woman	50	8929
				Man	70	12500
Cabbage	Imidacloprid	0.13	14	Child	20	25339
				Teen	40	50679
				Woman	50	63348
				Man	70	88688
Cantaloupe	Oxamyl oxime	0.24	0.1	Child	20	60
				Teen	40	119
				Woman	50	149
				Man	70	208
Cauliflower	Deltamethrin	0.041	1	Child	20	5739
				Teen	40	11478
				Woman	50	14347
				Man	70	20086
Eggplant	Acephate	0.7	0.5	Child	20	168
				Teen	40	336
				Woman	50	420
				Man	70	588
Grapefruit	Imazalil	0.067	1.25	Child	20	2665
				Teen	40	5330
				Woman	50	6663
				Man	70	9328
Mangoes	Thiabendazole	1.5	10	Child	20	952
				Teen	40	1905
				Woman	50	2381
				Man	70	3333
Onion	Boscalid	0.034	4.4	Child	20	30450
				Teen	40	60900
				Woman	50	76125
				Man	70	106574
Papaya	Boscalid	0.075	4.4	Child	20	8381
				Teen	40	16762
				Woman	50	20952
				Man	70	29333
Pineapples	Carbaryl	0.11	9.6	Child	20	12468
				Teen	40	24935
				Woman	50	31169
				Man	70	43636
Sweet corn	Acephate	0.004	0.5	Child	20	29412
				Teen	40	58824
				Woman	50	73529
				Man	70	102941
Sweet potatoes	Dicloran	3.7	50	Child	20	2457
				Teen	40	4914
				Woman	50	6143
				Man	70	8600
Sweet peas (frozen)	Dimethoate	0.005	0.05	Child	20	2353
				Teen	40	4706
				Woman	50	5882
				Man	70	8235

* EWG has included these commodities on current or past "clean 15" lists.