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How Much Pesticide is on My Plate?

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To this day, I have an irrational fear of deep water. I can swim well enough, but my imagination conjures up all kinds of creatures lurking below me ready to do me harm. I blame Steven Spielberg, director of the movie *Jaws*. After watching that I got the feeling that something close to a large shark is lurking in any body of water where I can't see the bottom. In my mind I know it is irrational to think that a great white shark would be prowling the waters of my favorite fresh-water swimming hole, but I still can't shake the feeling that something might be there. What does this have to do with pesticides in food? Some people have developed a great fear that something malevolent might be lurking in their food and they may be scared enough by this to avoid eating fruits and vegetables in the same way I fly out of murky water when something brushes my leg.

I think a few opening statements are useful for framing this discussion:

1. We have an emotional attachment to our food.
2. Very few people (if any) love pesticides.
3. The internet is full of inaccurate and misleading information.
4. Risk is inherent in everything we do.

With these in mind, let's examine the topic of pesticide residue in light of these statements.

Think of your favorite memories. It is likely that food is involved. For me, I have very fond memories of Memorial Day barbecues, Independence Day picnics, sumptuous Thanksgiving dinners, and wonderful Christmas treats. The thought that these events could be tainted by the presence of pesticides is enough to make a person respond emotionally.

Additionally, many pesticides are known to be toxic. The purpose for many pesticides (but not all) is to kill some type of pest. Many people wonder, "if it kills a pest, won't it hurt me?"

The internet has been used to blend these two thoughts to generate fear about the food on our plates. Fear is a powerful motivator and some popular internet personalities have learned how to promote fear in an effort to generate money. People like the Food Babe,[1] the Health Ranger,[2] Dr. Oz,[3] and Dr. Joseph Mercola[4] have garnered many followers by scaring people about food (see footnotes for examples), and then offering alternatives which they claim will make you safer. As I state above and will demonstrate below, much of this information is inaccurate and misleading.

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[1] https://foodbabe.com/they-just-banned-this-chemical-in-europe-but-its-still-used-on-american-food/
[2] https://worldhealth.net/news/70-produced-found-be-contaminated-pesticides/
[3] https://www.doctoroz.com/article/shoppers-guide-avoiding-pesticide-residues-your-produce
[4] https://articles.mercola.com/sites/articles/archive/2018/01/16/pesticide-residues-in-fresh-produce.aspx

While it is desirable to limit risk, it is not possible to eliminate risk. As a result, just because a risk is present with something, it doesn't mean that thing should be avoided at all costs. An accurate understanding of risk allows people to better choose whether the risk is acceptable.

With these thoughts in mind, let's look at the true risk of pesticides in our food. How much pesticide is on my plate? And more importantly, should I be worried?

To best answer these questions, we need to go back in time to 1996. That was the year the Food Quality Protection Act (FQPA) was unanimously passed by Congress.[5] FQPA required the Environmental Protection Agency (EPA) to increase efforts to protect human health and the environment. The EPA was to decide on safety tolerances for pesticides so that there was "a reasonable certainty of no harm" in their use. All pesticides were to be reviewed in the next 10 years and reviewed again every 15 years after that. The law called for increased scrutiny of the effects of pesticides on children by adding an additional 10X safety factor.

Prior to the adoption of FQPA, residues from different pesticides within the same class were treated independently. After FQPA, all uses of a product from all possible exposures (termed aggregate exposure) were considered together instead of separately (Figure 1). Additionally, the effect of pesticides with similar modes of action were considered cumulatively, instead of separately.

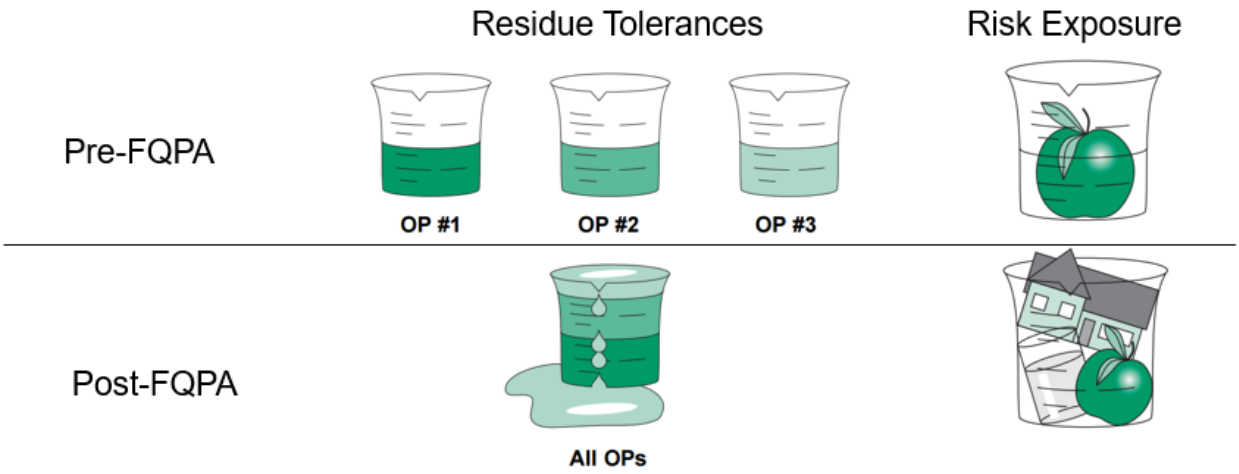

Figure 1. Comparison of separate (Pre-FQPA) assessment of pesticide safety to aggregate (post-FQPA) assessment of pesticide safety. In the Pre-FQPA example, three different organophosphate products are each evaluated separately and in the Post-FQPA example, all three are combined since they have a similar mode of action. Additionally, in the Post-FQPA example, multiple sources of exposure are accounted for as opposed to the single source (apples) shown in the Pre-FQPA example. (Adapted from *FQPA: The Food Quality Protection Act*, NC State University, AG-609.)

As of 2016, over 20,000 products have been reviewed under the guidelines of FQPA. From this review, 11,702 products have been cancelled and 40 have been suspended.

How does the EPA set a safety limits for pesticides in food? We first need to understand how toxicity is measured. Test animals are exposed to varying concentrations of a pesticide or pesticide break-down product. From these tests, scientists determine the concentration which is lethal to the test subjects. These levels are abbreviated as the LD_{50}, or the dose which is lethal to 50% of the population, and the LC_{50}, or the concentration which is lethal to 50% of the population. The LD_{50} is determined by dermal or oral exposure and the LC_{50} by inhalation.

[5] https://www.govinfo.gov/content/pkg/PLAW-104publ170/pdf/PLAW-104publ170.pdf

Exposure tests can be either chronic or acute. Chronic exposure studies are more difficult because they involve exposing test subjects to the substance in question over a long period of time. Acute studies are easier to conduct and to assess because the test subjects are exposed to a defined concentration one time and then monitored. In either case, the dose considered to be lethal is calculated as the concentration of the substance multiplied by the time of exposure.

Knowing how lethal a product can be does not help determine how much can be in food, however. Additional work is done to determine the NOAEL and ADI. The NOAEL is the no observable adverse effect level. It is determined from multiple toxicological tests and represents the highest concentration of a product at which scientists cannot measure any adverse response in the physiology of the test animals. The most sensitive test (the lowest NOAEL reported from multiple tests) is used to calculate this value.

The ADI, the acceptable daily intake, is a value which is 100 or 1000 times lower than the NOAEL. The reduction is used to account for potential differences in test animals, such as rats, and people. The 1000-fold reduction is used to provide an additional level of safety for babies and young children. All potential sources of a product in an average diet are used to determine the ADI. The ADI is the amount of a pesticide residue which can be found in food and still be considered safe.

This can be thought of as a path along a cliff. A line of solid ground near the edge of the cliff is safe, as long as I don't cross that line and get too close to the edge of the cliff. A path constructed along that line of solid ground would be the NOAEL. As long as I don't stray from that path, I will be safe. However, to take additional precautions, another path could be built significantly farther away from the edge. This additional path further away from the cliff's edge is analogous to the ADI.

And this is where pesticide labels come into play. Pesticide labels list the maximum amount of product that can be applied, along with restrictions on when it can be applied. These prescriptions were developed from research trials. If the maximum rate of a product is applied in accordance with the timings specified on the label, the pesticide residue found in the food will be below the ADI.

How can we be sure that following the label will do this? The USDA evaluates pesticide residues in food every year. This program is the USDA-ARS Pesticide Data Program (PDP). This program was started in 1991. A sample of food products (with emphasis on those that may be consumed by infants and children) are collected from over 600 sites representing approximately 50% of the U.S. population and all four census regions. Tests are conducted for over 450 pesticides and pesticide breakdown products. Over 10,000 samples are collected each year. Fresh and processed fruits and vegetables are evaluated every year. Other products evaluated recently are shown in Table 1.

Table 1. Products evaluated in the USDA-ARS Pesticide Data Program from 2016-2018.

2016	2017	2018
Fresh fruits and vegetables	Fresh fruits and vegetables	Fresh fruits and vegetables
Processed fruits and vegetables	Processed fruits and vegetables	Processed fruits and vegetables
Eggs	Honey	Rice
Milk	Milk	Wheat flour
Environmental contaminants	Bottled water	Heavy cream

How well are we (agricultural crop producers) doing as an industry? If we were to award a letter grade, it would be an A+. Over the last 7 years, over 99% of all samples tested had residues below tolerance, which is defined as the ADI (Table 2).

Table 2. Summary of Pesticide Data Program results from 2012 to 2018.

	2012	2013	2014	2015	2016	2017	2018
Samples	11,893	10,104	10,619	10,187	10,365	10,541	10,545
% No Detection	47.4	40.5	--*	15	23	53	48
% Below Tolerance	>99	>99	>99	>99	>99	>99	>99
% Above Tolerance	0.53	0.23	0.36	0.53	0.46	0.59	0.78
% w/o Tolerance	4.3	3.0	--*	3.9	2.6	3.3	6.1

* Data not accessible.

The summary statement of scientists working in the PDP program is that, "residues found in agricultural products sampled are at levels that do not pose risk to consumers' health and are safe according to EPA and FDA."[6]

It is true that some residues are above tolerance and some residues should not be present (% w/o tolerance) and effort must be made to eliminate these. However, the fact that over 99% of all residues are below tolerance is a testament to the effort growers are making to properly apply pesticide products.

Potatoes have been in the PDP program from 1991-1995, 1996-1997, 2000-2002, 2008-2009, and 2015-2016. The results from the 2015-2016 program are shown in Table 3.[7] It isn't too surprising that chlorpropham, the active ingredient in many sprout inhibitors, was the most common product detected since it is applied to the tubers after harvest. However, all detections were below the EPA tolerance.

Table 3. Pesticide Data Program results for potatoes evaluated from January 2015 to December 2016.

ACTIVE INGREDIENT	# DETECTS	% DETECTS	LOWEST DETECT (PPM)	HIGHEST DETECT (PPM)	EPA TOLERANCE (PPM)
Azoxystrobin	197	27.8	0.002	1.2	8.0
Boscalid	138	19.5	0.003	0.034	0.05
Chlorpropham	705	99.6	0.002	10	30
Clothianidin	94	13.3	0.003	0.032	0.3
Difenoconazole	81	11.4	0.002	1.8	4.0
Fludioxonil	66	9.3	0.020	0.93	6.0
Imidacloprid	301	42.5	0.002	0.11	0.40
Metalaxyl/Mefenoxam	54	7.6	0.002	0.017	0.5
Thiabendazole	47	6.6	0.002	3.1	10.0

Should the mere presence of these detections cause concern? The Environmental Working Group (EWG) thinks so. Each year the EWG publishes a list called the "Dirty Dozen" (in 2018 potatoes made the list at #12). The data from the PDP are the data used to generate this list of fruits and vegetables with the highest fungicides residues. However, as pointed out earlier, these residue levels are below the level scientific studies have shown to be safe. The EWG information is only based on the presence of residue, not the amount. In the end, the value of eating fruits and vegetables that may have trace amounts of fungicides far outweighs the potential risks of trace pesticides in food. The EWG essentially admitted this in a recent press release when they said:

[6] Pesticide Data Program, Annual Summary, Calendar Year 2017, www.ams.usda.gov/pdp, p. 19.
[7] Pesticide Data Program, Annual Summary, Calendar Year 2016, www.ams.usda.gov/pdp, Appendix H, p. 5 of 7.

> *"EWG recommends that whenever possible, consumers purchase organic versions of produce on the Dirty Dozen list. When organic versions are unavailable or not affordable, EWG advises consumers to continue eating fresh produce, even if conventionally grown."*[8]

The health benefits of eating fruits and vegetables are well-known and supported by a large body of scientific research. Unfortunately, this paragraph is included at the end of a long article pointing out the presence of pesticides in food.

In the end, does it matter if we are afraid of our food? After all, if people want to be selective about diet, is there any harm in that? Actually, there is. Research has shown that non-scientific messages about the presence of pesticides in food made low-income shoppers less likely to buy fruits and vegetables.[9]

We are used to using toxic substances in every-day life. Caffeine is considered more toxic than metalaxyl and mefenoxam (active ingredient in Ridomil and similar products) based on LD_{50} values. Benadryl and Flonase are more toxic than malathion and atrazine. Sodium chloride is more toxic than the phosphite fungicides that are recommended for *Phytophthora* control. But this doesn't mean that we should get rid of Coca-Cola, stop using allergy medicine, and get rid of our table salt. When used properly, these products don't harm us. In the same way, the pesticides don't either.

When I swim in the Snake River near my home, my mind assures me that there are no creatures like Jaws. I love swimming and I have worked hard to overcome this fear. Similarly, agriculture has a great story to tell about the safety of the food produced in the U.S. By following the label and telling our story, we can assure that this continues. Potato growers are doing a great job at providing us safe, healthy potatoes. Don't be afraid to tell this story! While some may never get over the Jaws-like fear of pesticides in our food, many will when they hear the true story.

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[8] https://www.ewg.org/release/just-released-ewg-s-2019-shopper-s-guide-pesticides-produce, Accessed 17 Jan 2020.
[9] Huang, Y. et al., Low-income shoppers and fruit and vegetables: What do they think? Nutrition Today 51:242-250.