# Consumer Reports' Methodology for Ranking Pesticide Dietary Risks

We rated 62 fruits and vegetables on chronic dietary risk from pesticides. We used the Dietary Risk Index system in conjunction with CR-adjusted pesticide toxicity factors to analyze the Department of Agriculture's Pesticide Data Program (PDP) test data. Our analysis included results from 28,819 samples.

## DATA COLLECTION

The USDA's Agricultural Marketing Service conducts the PDP each year to collect data on pesticide residues in food. The PDP tests a wide variety of foods for pesticide residues, with a focus on foods that are consumed by infants and children. The PDP chooses 12 to 15 types of foods to test every year, primarily fruits and vegetables.

In ranking the 62 foods, we used the most recent year (MRY) of PDP residue data from 2016 to 2023. The 62 foods include fresh, canned, frozen, and dried fruit and vegetable food forms. We also compared residues and risks in the 62 foods in the MRY in the 2016 to 2023 time period with residues and risks in the same foods in the 2012 to 2015 time period. For a limited number of items, we used data from earlier test years for this comparison because of the absence of PDP data from 2012 to 2015.

The PDP has developed extensive procedures that ensure samples are randomly selected from the national food distribution system. Samples are chosen such that the number of samples of a particular food from a given area is representative of each area's share of the national supply of that food. Hence, if sweet bell peppers imported from Mexico account for 22 percent of the national supply of peppers in a given year, the PDP would strive to select 22 percent of the samples of sweet bell peppers from imports from Mexico. The same general rule applies to the percentage of samples tested of organic foods.

The PDP uses trained inspectors who randomly collect samples at terminal markets and large chain-store distribution centers throughout the country. Samples are collected from nine states that account for about 50 percent of the U.S. population and represent all four census regions of the U.S. (West, South, Midwest, and Northeast). The PDP strives to test at least 600 samples per commodity per year (although this is not always the case) in order to provide an accurate statistical representation of a given commodity.

PDP sample collectors are trained to adhere to detailed program standard operating procedures that provide criteria for site selection and specific instructions for sample selection, shipping and handling, and chain of custody.

## TESTING

The PDP tests samples at ISO-17025-accredited laboratories. ISO-17025 accreditation demonstrates that the laboratory meets a global standard for testing and calibration, ensuring that it operates a quality management system, is technically proficient, and can produce precise and accurate test and calibration data.

The samples were tested for 595 parent pesticides, metabolites, breakdown products, and/or isomers, plus 20 environmental contaminants using multi-residue methods (MRMs). Testing laboratories used various QuEChERS-based approaches to analyze fruits and vegetables. (QuEChERS stands for "quick, easy, cheap, effective, rugged, and safe.")

All MRMs have been fully validated and run according to procedures that will ensure consistent results across all analytical labs. PDP laboratories used gas chromatography (GC) and liquid chromatography (LC) instrumentation coupled with tandem mass spectrometry (MS) detection systems for simultaneous identification/confirmation and quantification of pesticides. These GC-MS/MS and LC-MS/MS systems allowed the PDP to capture data for a broad spectrum of pesticides, including emerging product chemistries, and at relatively lower detection limits.
Before testing, each sample was prepared according to a uniform set of procedures to ensure consistency and to reflect how a consumer would prepare a fruit or vegetable before eating it.

For example, oranges and grapefruit were peeled, and any excess white membrane was removed. Apples and kiwis were washed for 15 to 20 seconds and drained but not peeled. Potatoes and sweet potatoes were held under cold running tap water, gently scrubbed with a clean vegetable brush, then washed and drained.

The PDP releases a report annually with its analysis of the test results. It also makes raw data in Excel files available to the public, which can be downloaded at https://apps.ams.usda.gov/pdp. We used the raw data incorporated in the Dietary Risk Index system for our analysis.

**ANALYSIS**

Using the PDP's residue data, we calculated dietary risk levels across each of the 62 foods and dietary risk levels for individual samples, taking into account each residue detected in a sample. We calculated individual sample aggregate risk levels by adding the Dietary Risk Index (DRI) value associated with each residue found in an individual sample.

The first step was establishing Consumer Reports-adjusted chronic Reference Doses for all pesticides. This was done by assuring that the full, tenfold added safety factor called for by the Food Quality Protection Act (FQPA) was in place for all pesticides known to pose certain risks: cancer, neurological damage, and endocrine disruption/damage to DNA. Such pesticides include organophosphates, carbamates, neonicotinoids, and synthetic pyrethroids.

We used the CR-adjusted chronic Reference Doses to calculate Food System-Dietary Risk Index (FS-DRI) values for five categories of samples within each of the 62 food items:
- All samples,
- Domestically grown conventional samples,
- Imported conventional samples,
- Domestically grown organic samples, and
- Imported organic samples.

Under the provisions of the 1996 FQPA, the Environmental Protection Agency was directed to add an extra tenfold safety factor in adjusting each pesticide's chronic Reference Dose (cRfD). The stated purpose was to more assuredly protect infants, children, pregnant people, and other vulnerable population cohorts from adverse impacts following pesticide dietary exposures. One exception was built into the FQPA. When the administrator of the EPA determines that there is ample high-quality data on pesticide toxicity and exposures to rule out any extra reproductive and developmental risks, the extra tenfold safety factor can be removed or reduced.

To distinguish between a chronic Reference Dose that has and has not been modified by the application of an added FQPA safety factor, the EPA calls a cRfD reduced by an FQPA safety factor a "Population Adjusted Dose," or PAD. A chronic PAD is designated as a cPAD, and an acute PAD as an aPAD.

The aggregate FS-DRI score for each of the 62 foods takes into account the following:

- The average amount of residue of each pesticide ("mean of the positives"): We first calculated the mean level of each pesticide detected in each of the four categories of each food item based on all positive samples (i.e., samples without detected residues are not included in the calculation of the mean). If a food item contained residues of multiple pesticides, the mean of the positives was calculated separately for each pesticide and added together to reflect "aggregate" DRI levels.
- The pesticide's chronic Reference Concentration (cRfC): The maximum level of residue that can be in a single serving of each food without overexposing a 16-kilogram child to the pesticide. The cRfC applicable to a given food-pesticide combination is calculated separately based on the CR-adjusted chronic Reference Dose for the pesticide and the typical serving size of each food for a 4-year-old child weighing 16 kilograms. The serving size of the food is a child's portion for each food item, calculated as approximately 2/3 of an adult's serving size.

The formula used to calculate the cRfC for a given food-pesticide combination is:
$cRfC\ Pesticide_x$ = (Weight of person x cPAD for $Pesticide_x$)/ Serving size of food.

For each pesticide ($Pesticide_x$) detected in a set of samples of a food item, a DRI-Mean (DRI-M) value is calculated using the following formula:
DRI-M ($pesticide_x$-$food_y$) = Mean of the positives for $Pesticide_x$/ $cRfC_x$

The Food Supply DRI (FS-DRI) is the DRI-M multiplied by the percentage of samples testing positive for a given pesticide.

**ADJUSTING THE DRI TO INCLUDE THE FQPA SAFETY FACTOR**

In calculating each pesticide-food combination's cRfC, we, in certain cases (described above), applied the Food Quality Protection Act's tenfold safety factor. We used these CR-adjusted chronic Reference Doses to calculate CR-adjusted DRI values. We refer to CR-adjusted chronic RfDs, and not CR-adjusted chronic PADs, to avoid confusion with Environmental Protection Agency-set cPADs. CR-adjusted cRfDs are used in our analysis to more closely adhere to FQPA mandates and to create more health-protective ratings. We applied the FQPA safety factor to any detected pesticide that is a neonicotinoid, a synthetic pyrethroid, an organophosphate, a carbamate, a neurotoxin, a carcinogen, or a potential endocrine disruptor.

To determine which pesticides to include in the list of potential endocrine disruptors, we used two resources:
1. The Endocrine Disruption Exchange (TEDX) database. The Endocrine Disruption Exchange was a nonprofit research

institute that operated from 2003 to 2019 and produced and shared scientific evidence of endocrine disruption. TEDX researchers evaluated chemicals by searching the publicly available scientific literature and identifying peer-reviewed research showing effects on endocrine signaling. TEDX developed a master list of potential endocrine disruptors, which are defined as chemicals with at least one study demonstrating endocrine-disrupting properties.
2. The European Commission's 2016 report detailing the findings of its "EU Impact Assessment Report on Criteria to Identify Endocrine Disruptors." We assigned the FQPA safety factor to all pesticides listed in the report under its "Option 3," which includes the following:
• Cat I: confirmed endocrine disruptor (ED). Adverse effects with a plausible link (i.e., same pathway) to mechanistic (endocrine mode of action) information or, in some specific cases, the pattern of adverse effects may be diagnostic of an ED mode of action.
• Cat II: suspected ED. Specific adverse effects, indicating endocrine disruption but without supporting mechanistic evidence or in vivo mechanistic evidence without evidence for adverse effects.
• Cat III: endocrine active. No in vivo evidence indicating endocrine adverse effects but mechanistic information in vitro.

**RATINGS**
Using the final score (the aggregate CR-adjusted FS-DRI score), we placed each food item's domestic conventional, domestic organic, imported conventional, and imported organic version (whenever data were available) in each of these four categories for which CR produced ratings.

DRI values can be used to array samples by zone along a Dietary Risk Continuum. The maximum number of servings in each zone that a child can consume per day without exceeding EPA's "level of concern" is shown below. The table includes the number of the 62 foods falling in each zone along the continuum.

**CR Ranking System: Number of Domestic Conventional Foods* by Zone Along the Dietary Risk Continuum Using the CR Rating Scheme**

| | Dietary Risk Continuum Zones | | | | |
|---|---|---|---|---|---|
| | **Very Low** | **Low** | **Moderate** | **High** | **Very High** |
| **OK Number of Servings per Day** | >10 | 3 to 10 | 1 to 3 | 0.5 to 1 | <0.5 |
| **DRI Range** | <0.1 | 0.1 to 0.329 | 0.330 to 0.99 | 1 to 1.99 | ≥2.0 |
| **DRI Risk Continuum Zone** | Very Low | Low | Moderate | High | Very High |
| | | | | | |
| **Number of Fruits** | 13 | 3 | 7 | 1 | 3 |
| **Number of Vegetables** | 12 | 10 | 5 | 6 | 2 |
| | | | | | |
| **Total Number of Foods** | 25 | 13 | 12 | 7 | 5 |

*For two items, bananas and frozen blackberries, sufficient testing data to calculate a risk score for domestic conventional versions was unavailable. In these cases, we've included the Imported Conventional score in the counts in this chart.