

Strawberries Are the Dirtiest of the 'Dirty Dozen'

Analysis by [Dr. Joseph Mercola](#)

✓ Fact Checked

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STORY AT-A-GLANCE

- › In 2018 EWG analyzed tests from the U.S. Department of Agriculture (USDA), which revealed close to 70% of conventionally grown produce samples contained pesticide residues
- › In all, 230 different pesticides and pesticide breakdown products were identified in more than 38,800 nonorganic samples
- › Strawberries ranked No. 1 in terms of pesticide residues, with up to 22 different pesticides found on a single berry; nearly all of the strawberry samples (99%) contained at least one detectable pesticide residue, while 20% contained 10 or more. In 2023 strawberries still top the list
- › More than 98% of samples of the top six “dirtiest” produce items (strawberries, spinach, peaches, nectarines, cherries and apples) contained at least one pesticide, while spinach contained 1.8 times more pesticide residue by weight than any other crop
- › The best way to avoid pesticide residues in your food is to choose those that haven’t been exposed to them to begin with, i.e., go organic

Editor's Note: This article is a reprint. It was originally published April 24, 2018. An updated 2023 Dirty Dozen list has been added for comparison.

Fresh produce, whether organic or conventionally grown, is one of the healthiest food choices you can make. Organic produce gains an edge, however, because it tends to be more nutritious, tastes better and, importantly, does not contain pesticide residues like

conventional produce does. In fact, the No. 1 reason people go organic is to avoid pesticides and other chemicals,¹ and the majority of Americans consume organic food at least occasionally.²

If your budget prevents you from buying organic food 100% of the time – or there's not an adequate selection in your area – it's useful to know which foods to prioritize over others. Namely, which conventional foods are the most contaminated and therefore the most important to buy organic?

Every year, the Environmental Working Group (EWG) releases their "Dirty Dozen" list for produce, which are among the most heavily contaminated with pesticides. For 2018, you'll see a familiar fruit earned the dubious top spot for the third year in a row: strawberries. In 2023, the list hasn't changed much. Various foods have exchanged spots on the list, but strawberries remain at the top.³

Nearly 70% of Conventional Produce Contains Pesticide Residue

EWG analyzed tests from the U.S. Department of Agriculture (USDA), which revealed close to 70% of conventionally grown produce samples contained pesticide residues. In all, 230 different pesticides and pesticide breakdown products were identified in more than 38,800 nonorganic samples.

While the Alliance for Food and Farming, a trade association that represents large produce growers and suppliers of pesticides and fertilizers,⁴ was quick to point out that 99% of pesticide residues on fruits and vegetables were below the safety levels set by the U.S. Environmental Protection Agency (EPA),⁵ a report commissioned by the European Parliament found negative health effects may occur in children even at current levels of exposure.^{6,7}

Part of the problem is that pesticide "safety" limits were based on animal studies looking at the effect of one pesticide at a time, but in the real world people are exposed to multiple pesticide (and other chemical) residues simultaneously. According to EWG senior analyst Sonya Lunder:⁸

"The EPA's tolerance levels are too lenient to protect public health. They are a yardstick to help the agency's personnel determine whether farmers are applying pesticides properly. The levels were set years ago and do not account for newer research showing that toxic chemicals can be harmful at very small doses, particularly when people are exposed to combinations of chemicals.

If pesticide tolerance levels were set to protect the health of children, who are more vulnerable than adults to small doses, more fruits and vegetables would fail EPA standards. The current EPA pesticide tolerances are like having a 500 mph speed limit – if the rules of the road are so loose it's impossible to violate them, no one can feel safe."

In research published in JAMA Internal Medicine, for instance, it was found that greater intake of fruits and vegetables with high pesticide residues was associated with a lower probability of pregnancy among women undergoing infertility treatment.⁹

Specifically, consuming two or more servings of high-pesticide residue produce daily was linked to a 26% lower chance of pregnancy compared to those who ate fewer servings. Consuming fruits and vegetables with high pesticide residues has also been linked to lower semen quality in men. According to the study, published in Human Reproduction:¹⁰

"On average, men in highest quartile of high pesticide residue fruit and vegetable intake (≥ 1.5 servings/day) had 49 percent ... lower total sperm count and 32 percent ... lower percentage of morphologically normal sperm than men in the lowest quartile of intake (< 0.5 servings/day) ... Low-to-moderate pesticide residue fruit and vegetable intake was associated with a higher percentage of morphologically normal sperm."

Strawberries Top the Dirty Dozen Produce List

As was also the case in 2016 and 2017, strawberries ranked No. 1 in terms of pesticide residues in 2018, with up to 22 different pesticides found on a single berry. Nearly all of

the strawberry samples (99%) contained at least one detectable pesticide residue, while 20% contained 10 or more. Residues of 81 different pesticides were detected in various combinations on the strawberry samples tested, EWG noted, with an average of 7.8 per sample.¹¹

For comparison, other produce contained an average of 2.1 pesticides per sample. Not only are strawberries among the most heavily sprayed crops, with close to 300 pounds of pesticides applied to each acre of California-grown strawberries,¹² but nerve gases are also used to kill pests and weeds on the soil prior to planting. Some of the most concerning chemicals used on strawberries include:

- Carbendazim, a hormone-disrupting fungicide that's banned in the European Union (found on 16% of the samples)
- Bifenthrin, an insecticide designated a possible human carcinogen by California regulators and the EPA (found on more than 29% of the samples)

As mentioned, toxic fumigants are also used to sterilize the soil prior to planting. While tarps are used to keep the gases underground, sometimes the gases (which include chloropicrin, the active ingredient in tear gas, and 1,3-dichloropropene, a carcinogen) leak out, polluting the air and putting farmers and nearby residents at risk.

Organic alternatives exist, including crop rotation, which cuts down on pests, and anaerobic soil disinfestation (ASD), which involves combining rice bran or molasses with topsoil, adding water and covering the land with a tarp to kill pathogens.¹³

The Full Dirty Dozen List

What other fruits and vegetables were found to contain the most pesticide residues?

The full 2018 EWG Dirty Dozen list is as follows:

1. Strawberries
2. Spinach
3. Nectarines

4. Apples
5. Grapes
6. Peaches
7. Cherries
8. Pears
9. Tomatoes
10. Celery
11. Potatoes
12. Sweet bell peppers

By 2023 the list hadn't changed much:¹⁴

1. Strawberries
2. Spinach
3. Kale, collard and mustard greens
4. Peaches
5. Pears
6. Nectarines
7. Apples
8. Grapes
9. Bell and hot peppers
10. Cherries
11. Blueberries
12. Green beans

There's also a 13th "baker's dozen" added to 2018's list: hot peppers. The analysis revealed the toxic insecticides acephate, chlorpyrifos and oxamyl, which are banned on certain crops, on some hot peppers tested. Because of their potential presence, EWG

recommends buying organic hot peppers if you eat them often, or at least cooking them first if you can't find organic, as cooking may help to reduce the pesticide residues.

Of note, more than 98% of samples of the top six "dirtiest" produce items ([strawberries](#), [spinach](#), [peaches](#), nectarines, cherries and [apples](#)) contained at least one pesticide, while spinach contained 1.8 times more pesticide residue by weight than any other crop.¹⁵ In the case of spinach, 76% of the samples contained permethrin residues. Permethrin is a pyrethroid insecticide — synthetic chemicals derived from natural chemicals found in chrysanthemums.

Animal studies suggest pyrethroids cause neurological, immune and reproductive damage while Canadian research suggests pyrethroids may be associated with behavior problems in children. A tenfold increase in urinary levels of one specific pyrethroid breakdown product doubled the child's risk of scoring high for parent-reported behavioral problems, such as inattention and hyperactivity, in one study.¹⁶ In Europe, permethrin is not allowed on food crops.¹⁷

Also noteworthy is the chemical diphenylamine, which was found on 80% of apple samples. The chemical, which is registered as a pesticide but does not kill insects, weeds or fungus, is sprayed onto apples after harvest to prevent dark spots from developing on the skin during storage. The European Union does not allow imports of apples treated with this chemical, citing concerns about the potential formation of cancer-causing nitrosamines on diphenylamine-treated fruit.

In the U.S., the EPA maintains that the chemical is safe, and Americans may be exposed every time they eat nonorganic apples. "Since Americans eat on average nearly 10 pounds of raw apples every year, even low levels of nitrosamines on apples could potentially pose a risk to human health," EWG noted.¹⁸

EWG's 'Clean 15'

If you're wondering which conventional produce contains the lowest pesticide residues, EWG compiled this list as well. The following make up the Clean 15 for 2018, which are

the produce items with the fewest pesticide residues detected:

1. **Avocados**
2. Sweet corn
3. Pineapples
4. Cabbages
5. **Onions**
6. Sweet peas, frozen
7. Papayas
8. Asparagus
9. Mangoes
10. **Eggplants**
11. Honeydew melons
12. Kiwis
13. Cantaloupes
14. Cauliflower
15. **Broccoli**

Among avocados and sweet corn, less than 1% of the samples contained pesticides, while more than 80% of pineapples, papayas, asparagus, onions and cabbages were also free from pesticide residues. None of the samples listed on the Clean 15 list contained more than four pesticides and only 5% contained two or more.

How to Avoid Pesticide Residues

Research shows that eating organic leads to lower levels of pesticides in your body. In one study, when a family of five switched to an all-organic diet for two weeks, their body

levels of pesticides dropped significantly, decreasing by a factor of 6.7.¹⁹ A separate study published in *Environmental Health Perspectives* came to similar conclusions.²⁰

It looked at the diets of nearly 4,500 people living in six U.S. cities, assessing exposure levels to organophosphates (OPs), which are among the most commonly used insecticides on U.S. farms. Those who ate conventionally grown produce were found to have high concentrations of OP metabolites, whereas those who ate organic produce had significantly lower levels.

Those who "often or always" ate organic had about 65% lower levels of pesticide residues compared to those who ate the least amount of organic produce. In addition to fewer pesticides, eating organic means you're eating GMO-free, as the use of genetic engineering, or genetically modified organisms (GMOs), is prohibited in organic products.

Not only are GE seeds prohibited but animals raised on organic farms may not be fed GE alfalfa or GE corn. You may also get more nutrition for your food buck. A British study found, for instance, that organically grown foods contain "significantly" higher levels of antioxidants than the conventionally grown variety, including beneficial compounds linked to a reduced risk of chronic diseases, including heart and neurodegenerative diseases and certain cancers.²¹

A Hungarian study reached a similar conclusion when they compared the chemical composition and nutritional value of organically and conventionally grown plant foods, with the organic variety again coming out on top with significantly higher amounts of vitamin C, polyphenols, flavonoids and minerals (along with lower levels of pesticide residues, nitrate and some heavy metal contaminations).²²

Overall, if you must choose between which products to purchase organic, I recommend prioritizing organic animal foods first and then using EWG's Dirty Dozen list for produce. For the nonorganic produce you consume, washing with a solution of baking soda may help to remove some of the pesticides on the surface of the fruit or vegetable,²³ although it won't remove chemical residues that have penetrated beyond the peel.

Peeling is another option to reduce pesticide residue, but this also means you're removing the healthy compounds contained in the peel (and there can still be residues that have penetrated into the produce flesh). For these reasons, the best way to avoid pesticide residues in your food is to choose those that haven't been exposed to them to begin with, i.e., go organic.

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