

# Pesticide Residue Monitoring

In 1906, Upton Sinclair’s novel *The Jungle* exposed conditions at Chicago meat-packing plants and triggered a public revulsion that pushed Congress into passing the Pure Food and Drug Act. It put the U.S. Bureau of Chemistry (later to become the U.S. Food and Drug Administration, FDA) in charge of protecting consumers against adulterated food and drugs.

## FOCUS ON PESTICIDE RESIDUES

Residues of toxic pesticides on food were but one of many food safety concerns beginning in the 1890s. It became a more frequent problem in the two decades that followed when farmers began using arsenic more often and in greater quantity to fight codling moth, potato beetle, grasshoppers and other pests. Federal authorities began a program to periodically examine fruit for pesticide residues, to educate farmers on the problem and to encourage them to not spray fruit excessively. Farmers also developed techniques to wipe or wash residues from their harvested crops.

Between 1920 and 1925, there were a number of reported illnesses, and well-publicized seizures of fruit with high arsenic levels by health officers. Despite these incidents, state and federal officials continued to stress farmer education and persuasion about potential problems of excessive pesticide use, rather than regulation.

In Great Britain, government control was stricter. After a 1900 tragedy in which 70 people died after drinking arsenic-contaminated beer, England imposed a limit on arsenic allowed in food, including fresh fruit. In 1925, English authorities began testing imports after a series of illnesses among British consumers of American-grown fruit. Finding arsenic residues above the allowable level, the British Health Ministry issued a warning not to eat imported apples. Sales of fruit grown in California plummeted. In response, California began analyzing small quantities of produce for pesticide residues in 1926. In 1927, the U.S. Bureau of Chemistry set the first federal limits (called tolerances) on arsenic residues on apples and pears in interstate commerce and for export. A tolerance is the amount of pesticide that may safely remain in or on fresh produce at time of sale.

## CALIFORNIA’S FIRST LEGISLATION

In response to Britain’s 1926 threat of an embargo, the California Legislature passed the Chemical Spray Residue Act (Statutes of 1927, Chapter 807) “to prevent the seizure of California fruits and vegetables on interstate and foreign markets.” The legislation made it illegal to pack, ship or sell fruits or vegetables with harmful pesticide residues. It gave the California Department of Agriculture (CDA) the authority to seize fresh products which, in the “judgment” of inspectors, “carry spray residue or other added deleterious ingredients,” pending chemical analysis. If analysis showed illegal residues, shippers were allowed to try to wash off the residues. The new law also set residue tolerances identical to those set by the federal government.



DPR scientists collect produce samples at a Southern California farmers market in 2013.



*The spray residue program protects the health of consumers of fresh and dried fruits and vegetables through sampling and analyzing produce to make certain that it does not carry spray residue in excess of the tolerances permitted by law.*

— 1947 California Department of Agriculture annual report

A second bill in 1927, the California Fruit and Vegetable Certification Act (Chapter 562), set up a fee-based program to allow farmers to get state certification that their crops were free of harmful residues.

By 1935, the California Department of Agriculture (CDA) was taking 22,000 samples a year in its voluntary certification program. (The department phased out this service by the 1940s.) It was also taking about 3,000 enforcement samples checking for illegal residues. For enforcement monitoring, inspectors made daily visits to wholesale and retail markets in Los Angeles, San Diego and San Francisco. Laboratories in those cities analyzed the samples. When illegal residues were found, the produce was quarantined and growers instructed on how to remove residues with an acid wash. Growers whose crops repeatedly had residues over allowable levels faced hefty fines and even jail sentences.

In 1934, the federal government set tolerances for residues of fluorine and lead. California followed suit and expanded monitoring to test for these residues. With the introduction of many new synthetic organic pesticides in the late 1930s and 1940s, the residue program began to test for DDT and other compounds. In 1949, the Spray Residue Act was amended to give the department authority to set pesticide residue tolerances. State laws passed in 1967 and 1983 reinforced California's right to review federal tolerances—to adopt them or to set stricter tolerances. In 1996, the federal Food Quality Protection Act (FQPA) preempted states from setting their own tolerances.

By 1950, with increased use of the new synthetic chemicals, CDA found few residues of arsenic, lead and fluorine. DDT was the most common residue found. Despite the wide variety of chemicals used, there were only four tolerances on the books: arsenic, lead, fluorine and DDT. In 1955, the FDA issued tolerances for 60 different pesticides on many crops.

In 1953, the California Legislature amended the Spray Residue Act to cover grains used to feed livestock or poultry. This was in response to the agriculture department's concerns that it could not take legal action in cases where pesticide misuse contaminated anything other than fruits or vegetables.

At the federal level, Congress amended the Food, Drug, and Cosmetic Act (FDCA) in 1954 to prohibit registration of any food-use pesticide that left residues unless the FDA issued a tolerance that sanctioned "safe" residue levels. In 1958, an amendment to FDCA, commonly referred to as the Delaney Clause, prohibited the use of any food additive shown to cause cancer in humans or experimental animals. Pesticide residue concentrations in processed foods at levels higher than those found in the raw agricultural commodity (e.g. whole tomatoes) were considered food additives and were thereby subject to the provisions of the Delaney Clause. However, pesticides that did not concentrate in processed foods were not considered additives and thus were not subject to the Delaney Clause. The 1996 passage of FQPA removed pesticide use from the Delaney Clause.

### INCREASING CONCERN PROMPTS EXPANDED PROGRAMS

The 1980s saw a dramatic increase in public concern about pesticide residues in food, particularly fresh produce. In 1984, the Natural Resources Defense Council (NRDC) published a report, *Pesticides in Food, What the Public Needs to Know*. Its theme was like many to follow: that government pesticide residue monitoring programs were not protecting public health.

In 1985, the Commission on California State Government Organization and Economy (Little Hoover Commission) published a report, *Control of Pesticide Residues in Food Products: A Review of the California Program of Pesticide Regulation*. The report called California's pesticide regulatory program "a leader in the country and in many ways exemplary in comparison to other states" but nonetheless noted "great uncertainties" in pesticide science. The report criticized

the California Department of Food and Agriculture (CDFA) regulatory program for failing to focus on “pesticides of greatest concern” and called enforcement sanctions “cumbersome, ineffective and inadequate.” The report also mentioned that CDFA lacked “the residue data necessary for estimating risk (and) detection methods for many pesticides.” The commission also faulted the Department of Health Services (DHS, later named the Department of Public Health) for failing to maintain an adequate program for pesticide testing of processed food. The commission described DHS’s monitoring program as “so minimal that it could not be said to be ‘routine’” and recommended transferring responsibility for testing produce destined for processing to CDFA.

Potentially harmful pesticide residues in food received worldwide attention in July 1985 when widespread illnesses were reported by consumers of California-grown watermelons. The fruit contained illegal residues of the pesticide aldicarb. This illegal application—a criminal act by a handful of growers—was cited in the years that followed as an example of the failure of the CDFA pesticide regulatory system.

Federal agencies that monitor the food supply were not free from criticism. The U.S. General Accounting Office targeted them in two 1986 reports—Pesticides: Better Sampling and Enforcement Needed on Imported Food, and Pesticides: Need to Enhance FDA’s Ability to Protect the Public from Illegal Residues.

In 1987, the National Academy of Sciences (NAS) issued a report that further reinforced public concerns about food safety. This report, *Regulating Pesticide Residues in Food: The Delaney Paradox*, examined the effect the Delaney clause of the Federal Food, Drug, and Cosmetic Act had on regulation of pesticide residues in food by the U.S. Environmental Protection Agency (U.S. EPA). As part of its examination, the NAS committee developed theoretical estimates of risk from dietary exposure to 53 potentially carcinogenic pesticides used on food crops. (The Delaney Clause, added to law in the 1950s, banned additives in processed foods that are found to induce cancer in humans or animals. The Delaney Clause was later repealed by FQPA.)

In 1988, the State Assembly Office of Research published *The Invisible Diet: Gaps in California’s Pesticide Residue Detection Program*, which was critical of both DHS and CDFA. And in March 1989, the NRDC issued the report, *Intolerable Risk: Pesticides in Our Children’s Food*. Its conclusion that preschoolers were exposed to dangerous levels of pesticides in both fresh and processed foods generated intense media attention and controversy.

The NRDC report also contributed to passage of California’s Food Safety Act of 1989 (Chapter 1200, AB 2161). The legislation declared that California “has the safest food in the world as a result of a combination of federal and state programs of pesticide registration, pesticide use controls, licensing persons who recommend and use pesticides, and monitoring food for pesticide residues and other contaminants.” At the same time, the bill noted that “(r)ecent events have heightened public awareness relative to food safety and led to a desire for additional regulatory practices to advance California’s food safety protections even further.” The statute:

- Required increased priority pesticide monitoring, focusing on pesticides of greatest health concern and dietary exposure, especially in children.
- Established a scientific advisory committee to review residue analytical methods and a committee to fund research into alternative pest management practices.
- Required risk assessments on the dietary exposure to pesticides in both raw and processed foods.
- Gave state pesticide regulators authority to call in acute toxicity studies where



**Illegal pesticide residues found on watermelons in 1985 helped spur reforms in the state's residue monitoring program.**



*There should be neither misunderstanding nor ill feeling if shippers everywhere met spray residue regulations, and it cannot be too strongly stated that it is economically entirely practicable to meet them.*

— 1938 California Department of Agriculture annual report

needed to support risk assessments.

- Required DHS to start a processed food monitoring program.
- Required private residue testing laboratories to be accredited and to send to the state findings of illegal pesticide residues in the channels of trade.
- Gave the CDFA clear statutory authority to require full pesticide use reporting. The data was to “be considered in setting priorities for food monitoring, pesticide use enforcement, farm work safety programs, environmental monitoring, pest control research, public health monitoring and research, and similar activities.”

The legislation (AB 2161) also mandated that CDFA and DHS jointly review state and federal pesticide registration programs to determine if infants and children were adequately protected from dietary pesticide residues. The review was to consider an evaluation of federal registration being done by NAS. When NAS released its report in June 1993, the California Environmental Protection Agency (CalEPA) formed the Pesticide Exposure to Children Committee (PECC), with scientists representing the California Department of Pesticide Regulation (DPR), DHS, the Office of Environmental Health Hazard Assessment, CDFA, U.S. EPA and the University of California.

In a 1994 report to the Legislature, the PECC concluded that “the current California and federal pesticide regulatory systems adequately protect infants and children from risks posed by pesticide residues in the diet.” The committee, however, noted “potential areas for improvement of the pesticide registration and food safety programs.” The committee called on DPR “in its role as the lead agency for pesticide regulation” to continue efforts to work with U.S. EPA “to achieve greater harmony in pesticide regulatory programs.” The committee also made several recommendations to improve risk assessments, many of which have been carried out. For example, the committee recommended that DPR and U.S. EPA assess pesticide risk not only from dietary food but also from other routes of exposure, including drinking water and home pesticide use. This approach was adopted by the end of the 1990s. Improvements in laboratory analytical methods answered the committee’s recommendation that residue detection limits be at levels “pertinent for risk assessment.”

### CALIFORNIA’S RESIDUE MONITORING PROGRAM

The flurry of interest and reports in the 1980s sparked many responses. In 1985, partly in response to the 1985 Little Hoover Commission report, the CDFA expanded the pesticide residue monitoring program. The Legislature added more than \$2 million to the department’s budget to almost double the samples analyzed and to create three new monitoring programs to supplement the Market-place Surveillance Program, which focused on retail channels of trade. The new programs, which began in 1987, were:

- Preharvest sampling of crops in the field, designed to detect the use of illegal pesticides before harvest.
- Postharvest sampling of raw produce destined for processing (established and funded by Chapter 1285, Statutes of 1985, AB 1397).
- Postharvest sampling of commodities known to have been treated with pesticides of health concern. This was called the Focused Monitoring Program and later the Priority Pesticide Program. The goal was to collect data to help make more accurate assessments of dietary risk.

With the passage of the Food Safety Act in 1989, the number of samples taken in the four monitoring programs reached an annual high of more than 12,500 samples in 1989. It remained high through the early 1990s before declining to

about 8,000 samples a year in 2000 and about 3,400 samples a year in 2014. Although smaller than in past years, the California Pesticide Residue Monitoring Program remains the most extensive state residue-monitoring program in the nation. DPR now contracts with the CDFA's Center for Analytical Chemistry to analyze samples.

During the 1990s, DPR improved its analytical capabilities. In 1988, residue program chemists were using multi-residue analytical methods (called screens) that could detect 108 pesticide active ingredients, metabolites and breakdown products. By 1991, that number had increased to more than 200. Today, CDFA's laboratories in Sacramento and Anaheim screen samples for more than 300 pesticide compounds and pesticide breakdown products. Results are usually available within 24 hours.

Budgetary cutbacks in 1992 and 1993 prompted DPR to first cut back and then end the preharvest and produce-destined-for-processing programs. They had been designed to address specific concerns and had achieved many of their goals. DPR concluded that their cessation would not adversely affect food safety because both programs had shown consistently lower percentages of detectable residues and lower rates of violations than in the broader Marketplace Surveillance Program.

In mid-2000, DPR combined the remaining two programs (Priority Pesticide and Marketplace Surveillance) to improve quality control over sampling and analysis. Combining the two programs resulted in significantly more data for dietary risk assessors. Under the earlier Priority Pesticide Program, there had been a limited number of samples taken of each commodity and each sample was typically analyzed for a single pesticide from among a small group of chemicals under regulatory scrutiny. In contrast, under the combined program, DPR takes a larger number of samples of each commodity and each is analyzed for multiple pesticides.

An added benefit is that all results are enforceable. Because the focus of the Priority Pesticide Program was data gathering, samples were typically not analyzed until days or weeks after the sample was collected. If illegal residues were found, no enforcement action could be taken because of the difficulty of investigative follow-up.

The combined program continues today as the California Pesticide Residue Monitoring Program. DPR samples individual lots of domestic and imported fresh produce (raw agricultural commodities) and analyzes them for pesticide residues. Sampling of processed food is the responsibility of the Department of Public Health (DPH) and the FDA. DPR collects samples from throughout the channels of trade—at packing sites, wholesale and retail markets, and farmers markets. DPR Enforcement Branch scientists collect most samples and county agricultural commissioners collect follow-up samples when investigating possible pesticide misuse.

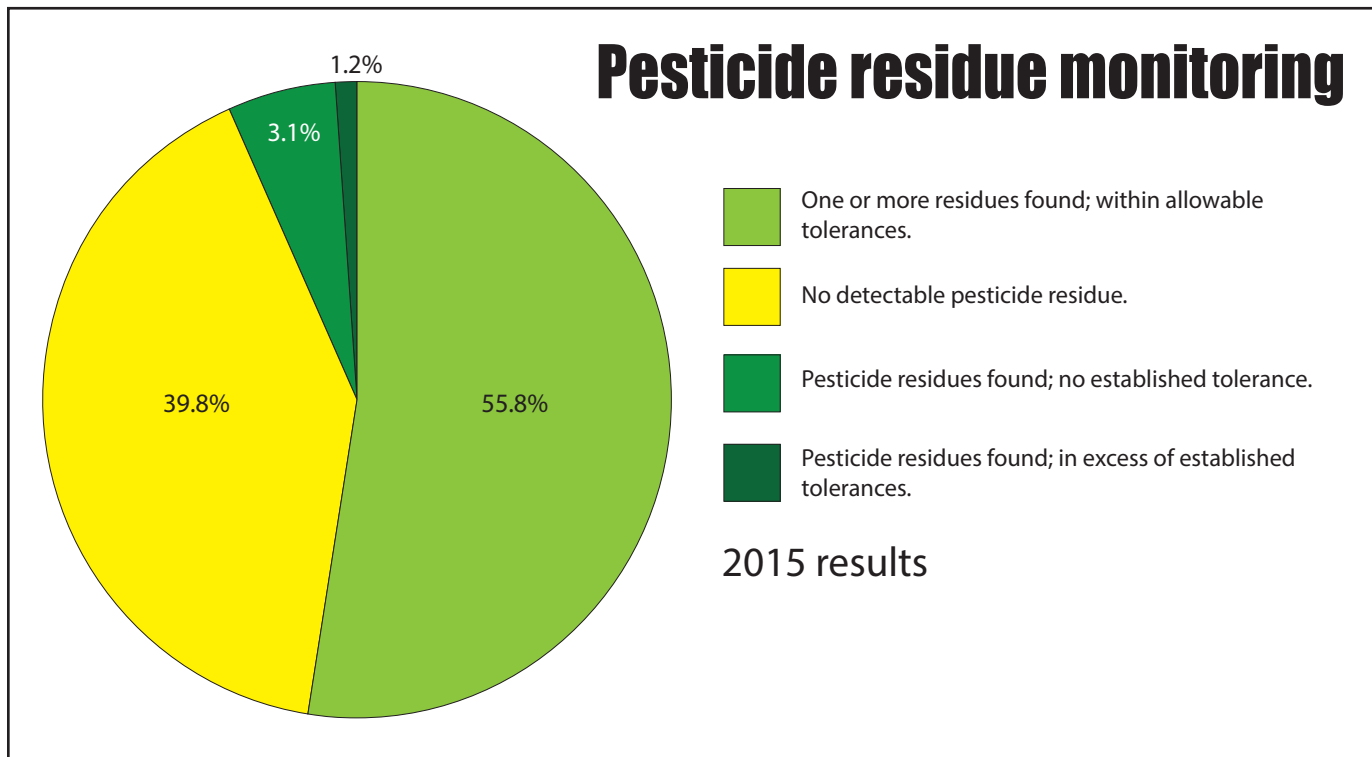
DPR samples commonly consumed commodities, with special emphasis on food consumed by infants and children and pesticides listed as causing cancer or reproductive toxicity. In addition, to ensure protection of all subpopulations, DPR selects commodities and sampling locations to reflect differences in consumption patterns of different cultural, ethnic and socioeconomic groups.

Residue monitoring is directed toward enforcement of U.S. EPA tolerances. If illegal residues are found (either above the tolerance or with no tolerance for that combination of commodity and pesticide), DPR immediately removes the illegal produce from sale, then verifies that the produce is either destroyed or returned to its source. In addition, if the owner of the commodity has similar produce from the same source, DPR quarantines those lots until the laboratory verifies it is free from illegal residues. Further, DPR traces the distribution of the illegal produce by contacting distributors throughout California, imposing quarantines



*Enforcement work must be reasonable, avoiding hysteria, and simultaneously evaluate all factors .... With continuation of careful enforcement, the proportion of low-residue fruits and vegetables continues to be satisfactory.*

— Dr. Alvin J. Cox, head of the department's pesticide regulatory program, in a 1941 article for the *American Journal of Public Health*



and conducting extra sampling as needed. DPR works with FDA and federal Immigration and Customs Enforcement to identify and eliminate sources of illegal residues in imported produce.

If investigators find there was illegal pesticide use, violators can be fined. For recurring or egregious violations, DPR can invoke additional sanctions.

DPR toxicologists review illegal residue detections to determine if adverse health effects can be expected by eating the tainted produce. Tolerances are set with a margin of safety so this seldom occurs. However, should it be necessary, DPR works with DPH to issue a health alert to warn consumers who may have purchased the produce.

DPR works actively with partners, including FDA, to identify and eliminate sources of illegal residues. (*See Coordination with Federal Agencies on Page 63.*) In addition, DPR collaborates with trade organizations and farmer-training projects, encouraging them to educate producers about pesticide residues in their commodities.

Nonetheless, DPR's sampling program is designed primarily to meet the goal of preventing "public exposure to illegal pesticide residues" (Statutes of 1986, Chapter 1375, SB 1889). For that reason, the data are not statistically representative of the residues typical for a particular pesticide, commodity or place of origin. Some sampling bias may be incurred by intentionally concentrating on such factors as commodity, place of origin with a history of violations, or large volume of production or import. In addition, the total number of samples of a given commodity analyzed for a particular pesticide each year may be insufficient to draw specific conclusions about overall residues for a commodity in commerce.

Under a statutory mandate (Statutes of 1986, Chapter 1375, SB 1889), DPR annually publishes a summary overview of the residue monitoring program in

the Pesticides in Fresh Produce report. The report and residue data are posted online at: <http://www.cdpr.ca.gov/docs/enforce/residue/rsmonmnu.htm>

### ANALYTICAL METHODS

DPR's samples are analyzed by the two laboratories of the CDFA Center for Analytical Chemistry located in Sacramento and Anaheim. Samples are analyzed as unwashed, whole (unpeeled), raw commodities as required by U.S. EPA regulations. Between 1991 and 2011, the CDFA laboratories analyzed all samples using multi-residue screens that could detect more than 200 pesticide active ingredients and breakdown products at the parts per billion level. In addition, selected samples were analyzed for nonscreenable pesticides of enforcement concern, using analytical methods capable of detecting residues well below U.S. EPA tolerances.

In 2012, the CDFA Center for Analytical Chemistry improved its capacity to detect pesticide residues. During that year, the CDFA laboratory in Sacramento replaced the "old" multi-residue screens with two new analytical techniques, LC-MS/MS (liquid chromatography—tandem mass spectrometry) and GC-MS/MS (gas chromatography—tandem mass spectrometry). These two techniques were implemented in CDFA's Anaheim laboratory in 2014. With LC-MS/MS and GC-MS/MS, CDFA can detect more than 350 pesticide active ingredients and breakdown products at the parts-per-billion level. The pesticide residues detected by these new analytical techniques include the residues detected using the "old" screens as well as residues of many active ingredients registered by U.S. EPA and DPR in the 1990s and beyond. The implementation of LC-MS/MS and GC-MS/MS increased the overall proportion of DPR samples on which pesticide residues are detected. Prior to 2012, CDFA detected pesticide residues in less than 40 percent of samples tested. In 2014, the proportion of DPR samples with detected pesticide residues was greater than 59 percent.

### COORDINATION WITH FEDERAL AGENCIES

The effectiveness of DPR's pesticide residue monitoring program is enhanced by collaboration with the FDA, which monitors raw and processed food nationwide. The two agencies share monitoring results and cooperate on investigations.

In addition, DPR carries out the California portion of the U.S. Department of Agriculture (USDA) Pesticide Data Program (PDP). California is one of 12 participating states. PDP is a national program that analyzes pesticide residues on agricultural commodities in the U.S. food supply, with an emphasis on those commodities consumed by infants and children. USDA also analyzes drinking water submitted by participating utilities. U.S. EPA uses the data to estimate dietary pesticide exposure.

Because accurate dietary exposure assessment requires data on even minute traces of residues, multi-residue methods were enhanced to be sensitive to residue levels of significantly less than 50 parts per billion. California's participation in PDP helped produce significant improvements to the multi-residue screens that can simultaneously detect many pesticides.



**A DPR scientist collects produce samples for residue testing from a grocery distribution center.**