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evidence review

Does Eating Organic Food Reduce Pesticide Exposures and Health Risks?

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Summary

- Diet is an important source of pesticide exposure, particularly for children, but data are lacking on the amount of pesticides consumed in the diet relative to exposures from other sources.
- Available data suggest that organically-grown food contains fewer synthetic pesticide residues than conventionally-grown food, and that eating an organic diet can result in lower exposures to some pesticides.
- However, there is currently no hard evidence that conventional food has a higher level of risk than organic food, due to a lack of research on the relative health risks and benefits of organically- versus conventionally-grown food.
- Consumers must weigh a variety of dietary and non-dietary factors when making food choices, such as cost, nutrition, food safety, and the environment.

Introduction

A pesticide is any substance intended for preventing, destroying, repelling, or mitigating a pest.[1] Pesticides include insecticides (to control insects), herbicides (to control weeds), and fungicides (to control fungi). Common types of chemical pesticides include organophosphates (OPs), pyrethroids, carbamates, and organochlorines (used historically).

Pesticide residues are substances that remain in or on air, water, soil, or food following its use. Even food grown without direct pesticide use can still contain residues due to spray drift from nearby farms, long range air transport, or existing groundwater or soil contamination.[2]

Diet is an important source of pesticide exposure, particularly for children.[3] However, data are lacking on the amount of pesticides consumed in the diet by age group as well as the contribution of pesticide exposures from the dietary pathway relative to other sources.[4] For example, pesticide exposures can occur from the inhalation of indoor and outdoor air, ingestion of dust from hand-to-mouth or object-to-mouth activities, ingestion of contaminated soil or water, and dermal absorption from dust or surfaces.[5-7]

Many studies have found an association between pesticide exposures and certain cancer and non-cancer effects, particularly in occupational settings, but other studies have yielded inconsistent results or found no clear evidence of risk.[8-11] There is currently no conclusive evidence linking low-level dietary pesticide exposures with adverse health outcomes in the general population.[12]

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Organically- Versus Conventionally-Grown Food

Organically-grown food is often perceived as posing fewer health risks or providing greater benefits than conventionally-grown food; consequently, consumers are often willing to pay higher prices for organic food.[13-14] In Canada, organic food consumption and production has grown dramatically over time, with 3,317 organic farms (1.3% of all farms) identified in 2003.[15] Federal regulations defining "certified organic" products were promulgated by the Canadian Government in 2009.[16] These requirements describe general principles, management standards, and permitted substances for organic production.[17-18]

Certified organic production is defined as a holistic system based on principles and practices that protect the environment and minimize pesticide use.[17] Although synthetic pesticides are generally prohibited during organic production, botanical pesticides (e.g., pyrethrum, rotenone, sabadilla, neem), mineral-based products (e.g., sulphur and copper-based fungicides), and biological pesticides (e.g., *Bacillus thuringiensis*), are permitted as crop production aids by the Canadian General Standards Board which sets standards for organic production systems.[17-18] Little is known about possible residues of these pesticides on organically-grown food, or potential environmental or health risks associated with their use.[2, 19]

Synthetic pesticide residues in food

Although data are limited, comparative studies suggest that organically-grown food typically contains fewer synthetic pesticide residues than conventionally-grown food. For example, in a study of pesticide residue data from three test programmes in the United States, organic fruits and vegetables were found to have fewer detections of synthetic pesticide residues, were less likely to have multiple residues, and had lower residue concentrations than either food grown using conventional or Integrated Pest Management (IPM) practices.[19] About 40% of the residues detected on organic samples were attributed to persistent organochlorine pesticides, whose use was restricted or banned in the 1970s and 1980s, but which remain ubiquitous in the soil. Residues of botanical or other natural pesticides permitted during organic farming were not analyzed.

In another study of infant and junior foods available on the Canadian retail market between 2001 and 2003, organic fruits and vegetables were found to have a lower detection frequency of synthetic pesticide residues than conventional produce.[20] Specifically, residues of two N-methyl carbamate insecticides (carbaryl and methomyl) were detected above analytical detection limits for conventional food groups only. No detections of five other N-methyl carbamates or the transformation products of aldicarb and carbofuran were found in any food sample.

Food items typically found to have the greatest detections and highest concentrations of synthetic pesticide residues include raw fruits and vegetables, fruit-containing products, peanut butter, and butter (milk and infant formula and food typically have few residue detections).[19-23] Detected pesticide residues, however, rarely exceed regulatory standards such as maximum residue limits established in the Canadian Food and Drug Regulations. Food processing treatments such as washing, peeling, and cooking have also been found to significantly reduce pesticide residues in prepared food.[24-25]

Biomonitoring of pesticide exposures

Only a few studies have attempted to assess pesticide exposures among children who consume organic diets compared to conventional diets (see Table 1). In the first study of this kind, 24-hour urine samples were collected from 18 preschool children with mostly organic diets and 21 children with mostly conventional diets in metropolitan Seattle, Washington in 2001.[26] Study participants were recruited from a convenience sample of two grocery stores that serve clientele with similar socioeconomic status (middle to upper-middle class). Urinary metabolites for five OP pesticides were analyzed, and two of these (DMTP and DETP) had the greatest overall detections and concentrations. Children with mostly organic diets were found to have significantly lower levels of total dimethyl metabolites in their urine than did children with mostly conventional diets, although total diethyl metabolite levels did not differ across the two groups. The study authors concluded that diet was the primary pathway of OP pesticide exposure for this population, but cautioned that the study participants were not necessarily representative of all children in Seattle.

In a separate series of studies, 23 elementary school children in suburban Seattle, Washington, who consumed only conventional diets, were recruited for a 1-year study conducted in 2003-2004.[27-30] Study participants were recruited from two local public elementary schools and a Montessori preschool, and families were screened via phone interview for eligibility. Children switched to organic diets for five consecutive days in the summer and fall, and urinary metabolites of five OP pesticides and five pyrethroid insecticides were analyzed at least twice daily during each of the four seasons. OP and pyrethroid urinary metabolite detections and concentrations were found to vary, particularly by season. Of the OP metabolites, TCPy and MDA were detected the most frequently, and were found to decrease to non-detectable levels as soon as children switched to organic foods. Of the pyrethroid metabolites, PBA, *trans*-DCCA, and *cis*-DCCA were detected the most often, and switching children to an organic diet reduced exposures by approximately 50% (but did not lower exposures to non-detectable levels). Very few samples had detectable levels of FPBA and DCBA. The study authors concluded that children in this small study were exposed to OP pesticides via dietary intake only, whereas for pyrethroid insecticides, dietary exposures represented only a fraction of the total exposure.

Although these studies provide preliminary data on potential dietary pesticide exposures among children consuming organic or conventional diets, larger nationally representative studies have not been conducted and no studies have attempted to quantify the relative health risks or benefits of organically- versus conventionally-grown food.

Other Dietary and Non-Dietary Considerations

Available studies do not provide any data with respect to potential health risk reductions or possible risk tradeoffs from eating organically-grown instead of conventionally-grown food. Consumers must ultimately consider and weigh a variety of dietary and other factors when making food choices, such as:

- *Nutritional quality of food* – the current weight of evidence indicates that there is no difference in nutritional quality between organic and conventional foods, although many factors related to production methods (e.g., harvest date, soil type) and farm location (e.g., climate) can influence the nutritional value of food, and these factors may differ between organically- and conventionally-grown food.[31-32]

- *Costs and benefits* – organic food is often more expensive than conventional food, but may provide additional perceived benefits to consumers, such as minimizing farm worker pesticide exposures or environmental impacts.[33]

- *Availability of food* – consumers may have limited access to organically-grown food, particularly in certain communities or during certain seasons, or may prefer food that is grown locally (organic or conventional) to imported organic food.

- *Exposure pathways* – studies of homes and day care centres show that children and adults can be exposed to pesticides from a variety of non-dietary pathways due to residential pesticide use.[5-7]

- *Food safety* – pesticide residues in food are likely to pose a small risk compared to other foodborne hazards, such as microbial pathogens, mycotoxins, and natural toxins, but data are lacking or inconclusive with respect to how these exposures and risks differ between organic and conventional food.[2, 34-35]

Conclusion

Currently, there is very limited data on dietary pesticide exposure levels, and no data on the relative health risks and benefits of consuming organically- versus conventionally-grown food. Available data suggest that organic food contains fewer synthetic pesticide residues than conventional food, and eating an organic diet can result in lower exposures to some pesticides. However, given the current weight-of-evidence, it cannot be concluded based on its potential for reduction of exposure to pesticides that an organic diet provides greater health benefits than a conventional diet, although organically-grown food may provide other perceived benefits to consumers.

Evidence Gaps

More research is needed to quantify (1) dietary and other sources of pesticide exposures among different segments of the population, (2) potential health effects from low-level dietary pesticide exposures, and (3) the relative risks and benefits of an organic versus conventional diet. In particular, there remain significant gaps in scientific knowledge with respect to differences in pesticide residue (synthetic and natural), microbial pathogen, mycotoxin, and natural toxin levels in organically-grown versus conventionally-grown food.

Table 1. *Studies of pesticide exposures among children who consume organic versus conventional diets*

Study and Location	Study Population	Methodology	Findings	Comments
Lu et al. 2009, 2008, 2006a, 2006b Suburban area in Seattle, Washington	23 elementary school children (3-11 years of age) who consumed only conventional foods were recruited for a 1-year study conducted in 2003-2004. Children's conventional diets were substituted with organic items including fresh and processed fruits and vegetables, juices, and some wheat or corn-based items (e.g., pasta, cereal, popcorn, chips) for 5 consecutive days in the summer and fall.	Urinary metabolites for five OP pesticides and five pyrethroid insecticides were analyzed at least twice daily during four seasons. OP metabolites: • MDA (malathion) • TCPy (chlorpyrifos) • IMPY (diazinon) • CMHC (coumaphos) • DEAMY (methyl pirimiphos) Pyrethroid metabolites: • PBA (permetrhin, cypermetrhin, deltamethrin) • FPBA (cyfluthrin) • *cis*-DCCA (many)* • *trans*-DCCA (permethrin, cypermethrin, cyfluthrin) • DBCA (deltamethrin)	For the OP pesticides, TCPy and MDA were detected the most frequently, and detected concentrations were found to decrease to non-detectable levels as soon as children switched to organic foods. The substitution of organic diets had no effect on the dietary exposures for IMPY, DEAMPY, and CMHC. For the pyrethroid insecticides, PBA, *trans*-DCCA, and *cis*-DCCA were the most frequently detected, and switching children to an organic diet reduced exposures by approx. 50% (but did not lower exposures to non-detectable levels). Very few samples had detectable levels of FPBA and DCBA.	The study authors concluded that children were exposed to OP pesticides via dietary intake only, whereas dietary exposures to pyrethroid insecticides represented only a fraction of the total exposure.
Curl et al.[11] 2003 Metropolitan area in Seattle, Washington	18 preschool children (2-6 years of age) who consumed mostly (>75%) organic juices and fresh fruits and vegetables and 21 preschool children who consumed mostly (>75%) conventional juices and fresh fruits and vegetables were recruited for study in June and July 2001.	Urinary metabolites for five dialkylphosphate (DAP) pesticides were analyzed based on 24-hour urine samples: • DMP • DMTP • DMDTP • DEP • DETP	DMTP and DETP were found to have the greatest detection frequencies and detected concentrations, and children with organic diets had significantly lower levels of total dimethyl metabolites in their urine than did children with conventional diets. Total diethyl metabolite levels did not differ across the two groups.	The study authors concluded that diet was the primary pathway of OP pesticide exposure for this population.

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