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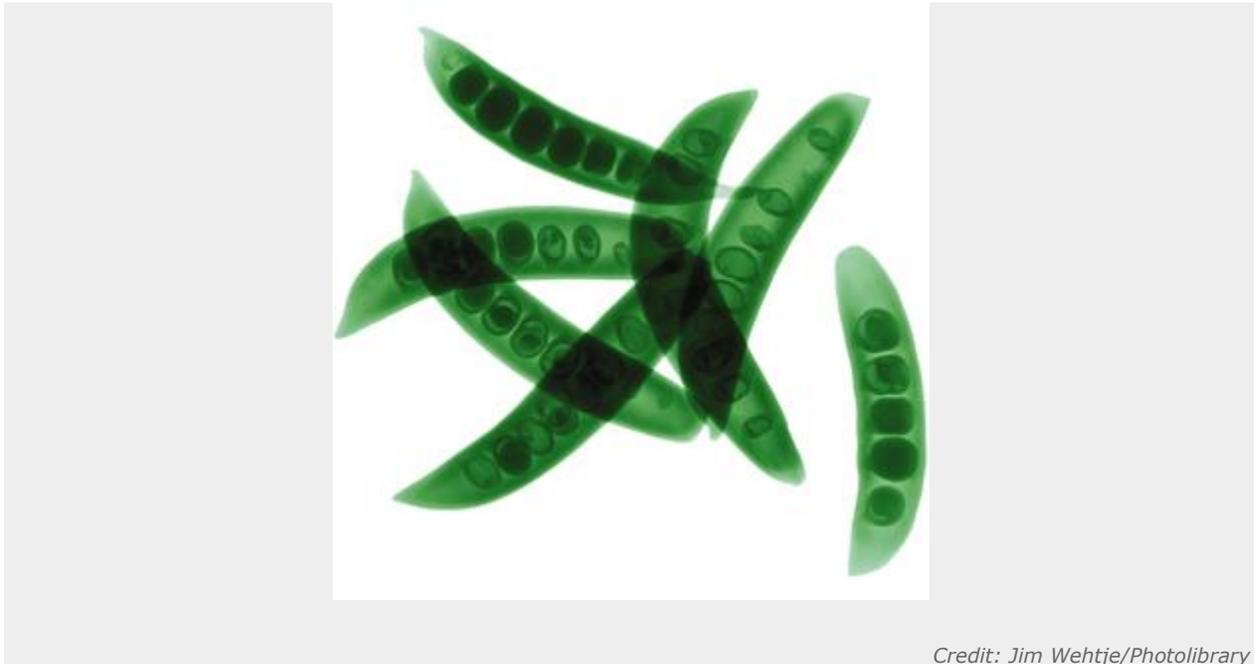
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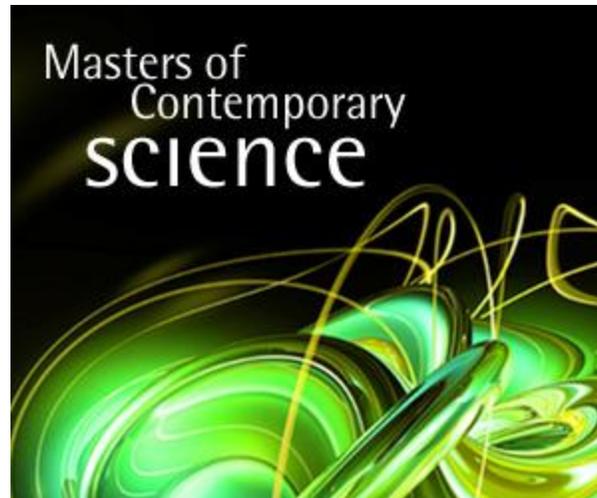
Organic food exposed

by Elizabeth Finkel

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It's a booming trend, driven by public perception that food produced minus pesticides and fertilisers is healthier and better for the planet. We examine the science to see if the evidence stacks up.





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I LOVE MY LOCAL ORGANIC FOOD STORE. From the moment I enter, I enjoy the aromas that greet me and the folksy look of the place. But is organic food really any better for me? The perceived wisdom is that it's more 'pure' and 'natural', devoid of disease-causing pesticides; that organic farming "generates healthy soils" and "doesn't poison ecosystems with toxic chemicals".

Organic food is riding a surge in popularity; across the globe, sales of organic food are burgeoning. The global market in 2006 was estimated at close to an impressive US\$40 billion (A\$47.9 billion) by Organic Monitor, an industry research body, and growing 20 per cent annually in the U.S. and Canada.

And where consumers go, the multinational food companies follow: everyone from Uncle Tobys to Kraft, Heinz, Kelloggs and even Coca-Cola has jumped on the bandwagon. And developing countries are joining in too: China's organic exports grew 200-fold in a decade to reach US\$200 million in 2004. Australia is also a major exporter, and plans to increase its organic produce by 50 per cent by 2012.

But is this belief in organic food based on faith, or evidence?

THE SURPRISING FACT IS that this mass migration to organic food has not been on the back of scientific evidence. In fact, you'd be hard pressed to find comprehensive evidence that organic food is healthier – either for us or the planet. Nevertheless, in the public consciousness, organic farming is unquestioningly bundled with the reigning moral imperatives of sustainability, protecting the environment and reducing greenhouse gases.

Certainly there are historical reasons for concern. In the 1950s and 1960s, the pesticide DDT was blamed for the widespread thinning of bird eggs across North America, and the rapid decline of the bald eagle and peregrine falcon. Over-intensive grain farming in the U.S. Midwest led to fertiliser runoff into the Mississippi River that ultimately created a 20,000 square kilometre dead zone in the Gulf of Mexico, as algal blooms sucked up available oxygen. Soils that were tilled for decades without crop rotation or replacing organic matter led to dust storms that wreaked havoc across Australia in the 1960s and the American and Canadian prairies in the 1930s, the latter so vividly depicted in John Steinbeck's *The Grapes of Wrath*.

These days, modern farming techniques have evolved after decades of pressure from the environmental movement and decades of work by a generation of scientists inspired by environmental awareness. In fact, conventional farming is starting to look a lot like organic farming.

The earthworm-rich soils, so prized by organic farmers, are being achieved through contemporary no-till (or no-plough) techniques. In Australia, most farmers use rotation to get crops out of synchronisation with weeds and to return nutrients to the soil. Natural predators are being used to control pests, and companies such as Dow Chemical are producing safe, short-acting pesticides. In fact Dow's latest pesticide, Spinosad, is also happily used by organic farmers because it is naturally produced by bacteria.

"There's been a quiet revolution in Australian farming over the last decade," says Mark Peoples, the assistant chief of the Division of Plant Industry at Australia's national research agency CSIRO.

ON THE OTHER HAND, organic farmers are bound to an ideology that demands they only use natural techniques. In some cases, such purism gets in the way of practices that are better for the environment and more sustainable for farmers. For example, organic farmers will use litres of BT spray (BT is a 'natural' pesticide made by the bacterium *Bacillus thuringiensis*), yet they often demonise the genetically modified (GM) cotton crops that carry an inbuilt supply of BT, and which therefore require less spraying.

However, these GM varieties spare farmers – and the environment – from the risks of pesticide overuse. For instance, according to Richard Roush, the Dean of land and food resources at the University of Melbourne, cotton farmers in India have reduced their use of pesticides and accidental poisonings by 80 per cent since the introduction of genetically modified BT cotton.

The ultimate test of sustainability is whether organic farming could feed the planet. Scott Kinnear, president of Australia's Organic Farmers Federation, believes "it is imperative that the world moves over to organic farming as soon as possible".

Yet many agricultural scientists estimate that if the world were to go completely organic, not only would the remaining forests have to be cleared to provide the organic manure needed for farming, the world's current population would likely starve.

Norman Ernest Borlaug, the American plant geneticist who won a Nobel Peace Prize for breeding the high-yield, disease-resistant wheat varieties (triggering agriculture's 'Green Revolution'), is despairing of the organic fad. "This shouldn't even be a debate. Even if you could use all the organic material you have – the animal manures, the human waste, the plant residues – and get them back on the soil, you couldn't feed more than four billion people."

TO GET HIGH YIELDS from food crops requires disturbing nature to deliver just what the crops need. First off, crops need fertiliser, which is often nitrogen in the form of nitrate and ammonia, because most plants can't draw nitrogen directly from the atmosphere. (Legumes are a famous exception – their root nodules hold bacteria that turn atmospheric nitrogen into nitrate.) Second, there has to be a way of stopping all the other robust plant and insect species from competing with or consuming your crop.

Non-organic farmers make use of chemicals to achieve these goals. Just prior to World War I, German chemists Fritz Haber and Carl Bosch learned to make ammonia synthetically. Their chemical reaction is still used today to produce more than 450 million tonnes of artificial fertiliser per year, and sustains the agriculture which feeds about 60 per cent of the Earth's population.

Organic farmers source nitrate from manures, gradually broken down by soil organisms. They use only naturally-occurring products to control pests, such as the elements sulphur and copper; pyrethrins and rotenone (both made by plants); BT spray and Spinosad (both made by bacteria). However, these natural pesticides are not harmless. For instance, sulphur irritates the lungs, and rotenone has been shown to cause Parkinson's disease in rats.

Certified organic farmers (those accredited by one or more of the six voluntary associations, from the Organic Growers of Australia to the National Association for Sustainable Agriculture) also subscribe to a code that includes kinder treatment of animals, a commitment to sustainability and environmental health, fair trade and social equity. But many of these practises are also pursued by 'non-organic' farmers. The core distinguishing belief of organic farming is that 'natural is better'. But does this conviction belief stand up to scientific scrutiny?

RACHEL CARSON'S 1962 book *Silent Spring* unleashed public concern about the dangers of synthetic chemicals, not just to birds and animals, but to humans. The incidence of human cancers were rising and suspicion fell on man-made farming chemicals.

There's no doubt exposure to high doses of pesticides is hazardous to health: in countless studies, high doses given to laboratory animals have caused birth defects, sterility, tumours, and damaged organs. But as any toxicologist will tell you, most chemicals – natural or synthetic, are toxic at high doses. The question is not, "do pesticides cause cancer?" Rather, do the small traces of pesticide residue we eat in our food really cause a problem?

Scientists are unable to test these chemicals directly on humans, so they use rats instead. To establish the maximum dose considered to be safe for humans, they find a dose that's completely safe for rats. Then they divide it by 100. Testing by Australia's national regulator, Food Standards Australia New Zealand, shows that pesticide levels measured in food are either well below the recommended maximum dose or are completely undetectable.

People live about 80 years longer than rats: that's 80 years longer for pesticide cocktails to accumulate and wreak havoc. Even so, it turns out that a lifetime's consumption of synthetic pesticides is a drop in the ocean compared to the natural pesticides we consume from the plants we eat. Plants have evolved a vast pharmacopeia of chemical weapons, and we consume many of these 'weapons' daily: caffeine in coffee, solanine in potatoes and psoralens in celery, to name just three.

Even the freshest organic apples – as well as other plant foods – contain natural compounds which, when extracted and given to rats in high doses, cause tumours. Toxicologist Bruce Ames of the University of California became famous in the 1970s for sounding the alarm on the cancer-causing (or carcinogenic) potential of man-made chemicals.

But after testing 'natural' pesticides in rats, he called off the warning. A paper he published in 1990 said it all. Entitled, "Dietary Pesticides (99.99 per cent All Natural)", it reported that in a regular diet, people consume about 10,000 times more natural carcinogens than synthetic ones. According to Ames, a single cup of coffee contains more natural carcinogens than a year's worth of the pesticide residues eaten on fruit and vegetables.

AMES IS NOT ALONE in his findings. A comprehensive review of some 400 scientific papers on the health impacts of organic foods, published by Faidon Magkos and colleagues in 2006 in the journal *Critical Reviews in Food Science and Nutrition*, concluded there was no evidence that eating organic food was healthier.

Even if it can't be proved that eating organic is healthier, advocates claim it is nutritionally superior. Some studies, especially those reported by the organic farming advocate group, the British Soil Association, show that organic produce has a higher content of vitamin C, minerals and anti-oxidants such as flavonols, polyphenols, lycopene and resveratrol.

However, some of the compounds present at higher levels in organic food are actually natural pesticides. According to Bruce Ames, a variety of insect-resistant celery had to be taken off the U.S. market in the late 1980s because its psoralen levels were eight times higher than normal and caused a rash in people who handled it. There was a similar story with a naturally pest-resistant potato variety that ended up being acutely toxic because of its high levels of solanine and chaconine – natural toxins that block nerve transmission and cause cancer in rats. Organic farmers who rely on 'naturally resistant' plant varieties may also be producing plants with high levels of 'natural' toxins. And in this case, 'natural' is not likely to mean better. Think of Abraham Lincoln's poor mother, who died after drinking the milk of a free-range cow that had grazed on a snakeroot plant.

Regardless of how it is grown, the nutritional content of fruit and vegetables is more likely to be affected by freshness or varietal differences. One study reported by Magkos tried to narrow things down by growing the same variety of plums in adjacent fields, with one using organic and the other conventional methods: the conventionally grown plums contained 38 per cent more of the potentially beneficial polyphenol compounds than the organically grown ones did.

The bottom line is that there is tremendous variation in the nutritional make-up of fruit and vegetables regardless of whether they were grown by organic or conventional means.

In fact, it is so difficult to support the claim that organic food is healthier that the Britain's Advertising Standards Authority has directed the British Soils Association – an organic foods advocacy group – to desist from making it.

IF CHEMICAL PESTICIDES ARE hazardous to health, then farm workers should be most affected. The results of a 13-year study of nearly 90,000 farmers and their families in Iowa and North Carolina – the Agricultural Health Study – suggests we really don't have much to worry about. These people were exposed to higher doses of agricultural chemicals because of their proximity to spraying, and 65 per cent of them had personally spent more than 10 years applying pesticides. If any group of people were going to show a link between pesticide use and cancer, it would be them. They didn't.

A preliminary report published in 2004 showed that, compared to the normal population, their rates of cancer were actually lower. And they did not show any increased rate of brain-damaging diseases like Parkinson's. There was one exception: prostate cancer. This seemed to be linked to farmers using a particular fungicide called methyl bromide, which is now in the process of being phased out. According to James Felton, of the Biosciences Directorate of the Lawrence Livermore National Laboratory in California, who also chairs the study, "The bottom line is the results are coming out surprisingly negative. It's telling us that most of the chemicals we use today are not causing cancer or other disease."

And as a flurry of papers cited in Faidon Magkos's review will attest, organic food has been subject to its own food scares. There have been bacterial outbreaks which have been blamed on the fact that organic production involves manure but not antibacterial techniques such as food irradiation or chemical washes. Another concern is the growth of moulds such as aflatoxin B1, commonly found on mouldy peanuts and one of the most carcinogenic compounds known to exist. Among the most notorious recent toxic mould scares was one linked to organic apple juice, where levels of the toxin patulin were 10 times greater than those found in regular apple juice. Levels of the mould toxin deoxynivalenol have also been reported to be higher in organic wheat. Because organics are not treated with fungicides, there is a higher risk of these toxins creeping in.

But as with anything to do with plants, the variations in the levels of these toxins is enormous, and contamination can be found in conventional as well as organic produce. Probably the only lesson to be learned from all this is that as far as human health is concerned, pesticide residues in fruit and vegetables are probably the least of our concerns.

Historically, most food-related diseases are due to bacterial and fungal contamination, so in terms of health consciousness, focussing on pesticides is probably barking up the wrong tree.

ADVOCATES OF ORGANIC FARMING argue that it is better for the environment and more sustainable. But is it?

Australian farmers are considered among the most innovative in the world, growing their crops in difficult conditions on ancient, infertile soils that have an unfortunate tendency to blow away in clouds of dust. One high-tech solution is known as no-till farming. The plough may be the icon of farming, but it turns out that ploughing actually wrecks the soil. The soil that farmers prize has a structure that resembles a stack of peas with pores running through it. Earthworms and other creatures maintain this structure, and the whole thing is meshed together by the tendrils of fungi and plant roots. In other words – a spongy soil that holds onto water and won't blow away. Too much tillage destroys that structure, so a method of no-till farming had to be developed.

Tillage is used to bury the previous year's crop residue and destroy weeds. But in no-till farming, herbicide removes the weeds and the new seed is sown directly into the stubble of the last crop. Leaving the stubble in the soil means the planet benefits. Roush estimates that all that carbon kept in the ground by no-till farming reduces carbon dioxide emissions by up to eight million tonnes per year.

Compared to the bad old days where virtually every part of a field was ploughed, these days the scars are restricted to two-centimetre-wide furrows 30 cm apart. No-till systems also win hands down when it comes to hanging on to soils. An 11-year farming experiment by the U.S. Department of Agriculture in Beltsville, Maryland, compared crops grown three ways: conventional tillage, organic methods, or no-till. Compared to the conventional tilled plot, the organic plot was likely to hang on to 30 per cent more soil. But compared to the organic plot, the no-till plot hung on to 80 per cent more soil. (It's possible to combine organic and no-till on a small scale by relying on hand weeding. But that's not practical for large-scale farming. And without tilling, it's difficult to work manures into the soil.)

THE DOWNSIDE to no-till farming is that steel ends up being replaced with chemicals: herbicides control the weeds. But in areas where soil erosion is a major problem, that is probably a fair trade-off, especially bearing in mind that most chemicals do their damage when they piggyback into waterways on the back of eroded soils. David Pimentel is a Cornell University entomologist who has written much about the negative environmental impacts of pesticides. Nevertheless he says, "I'd take chemicals over soil erosion any day."

Australian farmers also practise the time-honoured tradition of crop rotation; for instance alternating a nitrogen-guzzling wheat crop with a nitrogen-producing legume such as clover. Not only does the clover pasture fertilise the field, but the unwelcome pests and weeds that adapt themselves to the wheat-growing schedule (wheat is planted in spring) get left high and dry when the winter clover is planted. So the farmers reduce their chemical use and are actually able to supply about 70 per cent of their nitrogen needs from the legumes.

"Our broad-acre cropping is at the very low end of the spectrum as far as chemical inputs," says John Kirkegaard, an agronomist at the CSIRO. In places like Western Australia with its poor soils, 100 per cent of broad-acre farmers use these environmentally-friendly techniques. "It's an economic imperative as much as an environmental one," he says.

Australian farmers, like those all over the world, have also reduced their use of pesticides because of the impact of a discipline that started more than three decades ago, known as integrated pest management (IPM). The first line of defence is to take advantage of natural insect or animal predators. Pesticides, targeted at specific pests, are a last resort. According to David Pimentel, integrated pest management has slashed the use of pesticides by over 65 per cent in Thailand and Switzerland.

PESTICIDES HAVE ALSO grown safer as regulatory authorities raise the bar and chemical companies oblige. In August 2006, after a 10-year review of pesticide safety, the U.S. Environmental Protection Agency (EPA) recommended cutbacks on the use of several pesticides – but these were overwhelmingly to protect against accidental workplace poisonings. "For the chemicals that are currently listed, I'm very confident that there is no risk to the general population through the diet," says Jim Jones, director of the agency's pesticide program.

There was also relatively little concern about the impact of pesticides in the environment. One exception was lindane, an organochlorine which accumulates in animal fat and is now largely restricted. This was deemed to pose a risk to indigenous people living above the Arctic Circle because of their high-fat diet. As far as the agency is concerned, the current batch of allowed agricultural chemicals are safe for consumers and the environment.

It's almost an axiom that pesticides are to blame for our major ecological problems. But once again, finding the evidence turns out to be a little difficult. Like many of today's environmental warriors, the University of Melbourne's Richard Roush was called to arms after reading Carson's *Silent Spring*. But after 30 years working in land management and sustainability, he thinks it's finally time to admit victory in the war on pesticides. "We've come a long way since *Silent Spring*... I am hard-pressed to think of a case where we can now attribute an environmental disaster to pesticide use."

In fact the only one that sprang to mind for Roush was a case of pyrethroids and fish abnormalities (pyrethroids are a synthetic version of plant-derived pyrethrins; the source turned out not to be not agriculture, but urban gutters. The finding stunned Roush. "Farmers have been trained for 20 years not to use chemicals where they could wash into streams; the problem was city people using pesticides to control household pests in a frivolous way."

Some of the blame for frog declines is often laid at the feet of agricultural pesticide run-off, but nailing such a link has proved elusive. In fact, frog losses from California's high Sierra have been much more convincingly linked to trout introductions. And chytrid fungus has proven the more likely culprit in many other cases of frog declines (see "Amphibian annihilation", p72). "[As far as frog extinctions go], I am much more concerned with global warming and the encroach of exotic species than pesticide run-off from farms," says Roush.

Environmental groups such as the World Wide Fund for Nature seem to have tacitly acknowledged that the judicious use of chemicals is the sustainable way to go. In 1996, they formed the non-profit group Protected Harvest with Wisconsin potato growers and the University of Wisconsin. Its goal: to develop ecologically sound principles for potato farming. The farmers reduced their use of chemical and natural pesticides using the principles of IPM and they also became better custodians of their non-farmed land by introducing native species and maintaining biodiversity.

"We're just starting to see market penetration as larger corporations get interested," says Deana Knuteson, a former University of Wisconsin entomologist who is now an education officer for Protected Harvest. With their high yields and good economic returns, she says they are confident about being able to expand to other vegetables.

ACCORDING TO VACLAV SMIL, an agronomist at Canada's University of Manitoba and an expert on the history of nitrogen fertiliser production, about 60 per cent of people today are fed thanks to the use of artificial nitrogen fertiliser.

Take that away, and all that nitrogen has to be produced organically – effectively using land to produce manure rather than food. Alex Avery, director of food research and education at the Hudson Institute, a conservative U.S. think tank, estimates that this would require doubling the amount of land now in cultivation. That would mean tearing down our remaining forests, he argues.

Even so, the poor yield of organic farming means that food production would be a major problem. In Australia, for instance, organic farming yields 50 per cent or less per square kilometre because of pest problems and phosphate-depleted soils. (Phosphate is locked away in the ancient clays; conventional farmers help themselves to highly soluble chemically-made superphosphate. Organic farmers can't use a chemical, so they use poorly soluble rock phosphate.)

In the late 1990s, Denmark seriously considered converting to 100 per cent organic agriculture. A report chaired by Svend Bichel, a former president of the Danish Society for the Conservation of Nature, concluded that should this occur, food production would drop by half.

There is one way the world can feed all the billions alive today with organic farming: we all go vegetarian. Half the world's grain is grown for cattle, and this is undeniably a highly inefficient use of soil, farming land and resources. But the reality is that the demand for meat, is – thanks to the growing wealth of developing nations – forecast to double by 2030.

Popular or not, it's clear that organic food is not necessarily healthier, nor more sustainable or better for the environment. With the Earth's climate changing fast, and the human population heading for nine or 10 billion, we need solutions based on scientific evidence rather than faith and good intentions.

The boutique organic foods café is a great place to enjoy the romantic idyll of traditional farming and natural foods, but when it comes to the reality of feeding the world, one would have to agree with Roush: "If improving sustainability and reducing the environmental footprint is the goal, we need to be prepared to use the best tools we have."

Elizabeth Finkel is a Melbourne science writer, a contributing editor of *Cosmos* and the author of *Stem Cells: Controversy on the Frontiers of Science*.