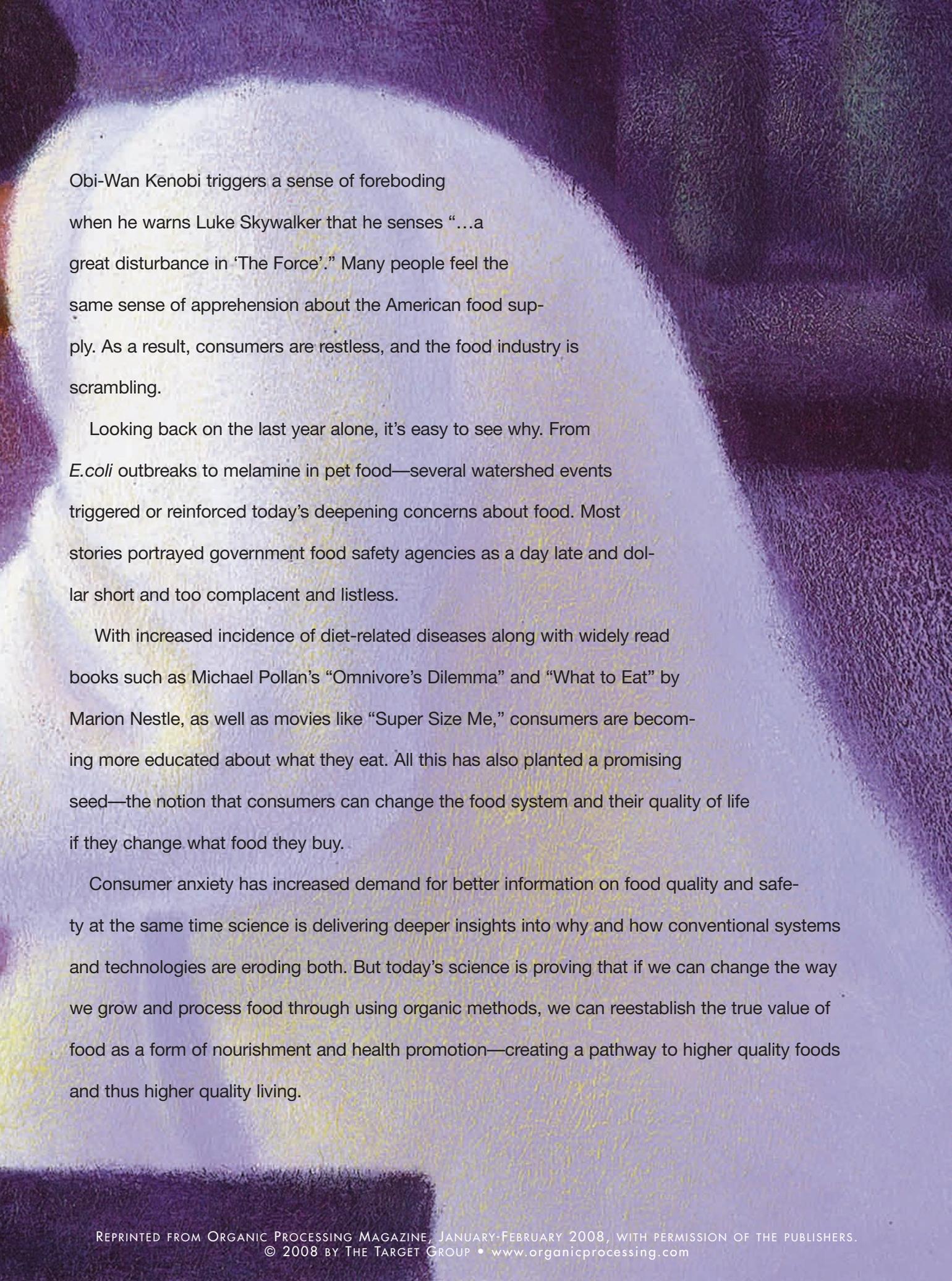


**THE LINK BETWEEN
ORGANIC AND HEALTH:**

New Research Makes the Case for Organic Even Stronger



By Charles Benbrook, PhD and Alan Greene, MD



Obi-Wan Kenobi triggers a sense of foreboding when he warns Luke Skywalker that he senses "...a great disturbance in 'The Force'." Many people feel the same sense of apprehension about the American food supply. As a result, consumers are restless, and the food industry is scrambling.

Looking back on the last year alone, it's easy to see why. From *E.coli* outbreaks to melamine in pet food—several watershed events triggered or reinforced today's deepening concerns about food. Most stories portrayed government food safety agencies as a day late and dollar short and too complacent and listless.

With increased incidence of diet-related diseases along with widely read books such as Michael Pollan's "Omnivore's Dilemma" and "What to Eat" by Marion Nestle, as well as movies like "Super Size Me," consumers are becoming more educated about what they eat. All this has also planted a promising seed—the notion that consumers can change the food system and their quality of life if they change what food they buy.

Consumer anxiety has increased demand for better information on food quality and safety at the same time science is delivering deeper insights into why and how conventional systems and technologies are eroding both. But today's science is proving that if we can change the way we grow and process food through using organic methods, we can reestablish the true value of food as a form of nourishment and health promotion—creating a pathway to higher quality foods and thus higher quality living.

Food Quality

The American diet is a perplexing paradox—we are an overfed, yet under-nourished nation. Daily deficiencies exist despite the abundance of nutrient-dense foods available to all Americans and our ample, often excessive, caloric intake. This is why scientists have begun work in earnest on reversing the decades-long decline in the nutrient density of high-yield conventional crops and why organic farming's potential to increase the nutrient density of food is emerging as such an important consumer health benefit. Surely food safety, quality (taste and nutrient density), and where and how the raw ingredients were grown, and then processed and manufactured into a final product, will be part of defining this new value proposition.

Specific Health Benefits of an Organic Diet

From heart-healthy fats in milk to cancer-fighting flavonoids in tomatoes—more and more studies are linking specific organic products to significant health benefits.

Healthy Fats

Studies have shown that organic dairy and meat have higher levels of conjugated linoleic acids (CLAs), a good fat that has been shown to have a long list of health benefits from helping fight cancer and enhancing immunity, to ridding the body of fatty, artery-clogging plaque. This higher number of fatty acids is due to the difference in the animals' diets—the greater the reliance on pasture in organic dairy farming, the bigger the boost expected in CLA levels.

Now these increased levels of CLAs in organic are being linked with other benefits. In the August 2007 *British Journal of Nutrition*, European scientists reported that children consuming a predominantly organic diet (greater than 90 percent organic) had over a 30 percent lower risk of eczema, compared to children eating 50 percent or less organic food. Higher levels of CLAs (conjugated linoleic acids) were identified as the most likely reason.

Earlier, in June, the same team reported another significant finding—lactating women consuming the most organic milk and meat had almost 40 percent higher levels of CLAs, specifically rumenic acid, in their breastmilk. This conclusion was based on a study of 312 breastfeeding women, who were divided into groups on the basis of how much organic milk and meat they consumed.

Antioxidants

New science is highlighting the critical role of dietary antioxidants in preventing or slowing the neurological diseases of aging, combating diseases rooted in inflammation and reducing the risk of cancer.

The Organic Center's 2005 "State of Science Review" on antioxidants concluded that organic farming and food processing increased average antioxidant content by about 30 percent, a finding reinforced by several recent studies and reports. Indeed, we think the debate over whether organic farming increases the total antioxidant content of foods under most circumstances will be largely settled by the end of 2008.

This is why the Center turned its attention in 2007 to two key questions: Why and how does organic farming increase the density of nutrients, including antioxidants, in food? And,

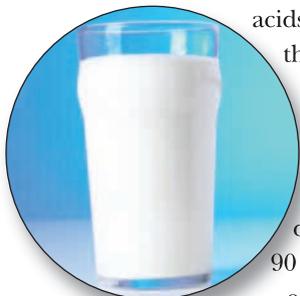
"The linkage between improved soil quality and more nutrient dense food stands as powerful evidence...feed the soil to better feed the plant."

does organic farming and food processing change the form of nutrients in ways that result in higher food quality?

Researchers at Washington State University, with support from The Organic Center, carried out the first-ever assessment of the bioavailability of the three major antioxidants in citrus fruits and juices: hesperetin, naringenin and eriodictyol. These key flavonoids are present in foods in two forms which have been shown to have major differences in biological activity. Lead scientist Dr. Neal Davies and his team at WSU were the first team to ever quantify both the glycoside (molecule with attached sugars) and aglycone (a more bioavailable molecule without sugars) forms of these three beneficial flavonoids. They found that:

- Organic lemon juice had ten-times the total eriocitrin (glycoside form of eriodictyol) compared to conventional lemon juice and the aglycone form had over three-times the level in conventional juice.
- Organic lime juice also had three-times the level of eriocitrin, compared to conventional lime juice.
- Organic apple juice had over three times the total hesperidin (glycoside), and almost twice the hesperetin (aglycone form).
- Organic grapefruit juice had about 20 percent less total hesperidin (glycoside), but 77 percent more hesperetin (aglycone).

The importance of measuring both the glycoside and aglycone form of flavonoids (and other nutrients) is



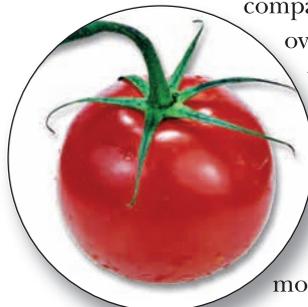
Organic milk has up to 40 percent more healthy fats.

clear in the grapefruit juice findings. Based on data encompassing just the glycoside form of hesperidin, conventional grapefruit juice appears to contain more of this flavonoid than the organic juice. But by focusing on the more bioavailable aglycone form, the opposite conclusion would be reached. The findings of this research, and other projects carried out by this WSU team, highlight the need for scientists to look more deeply at how and why organic farming and processing methods often change the form of nutrients in ways that enhance nutrient bioavailability and food quality.

While other factors such as genetics can have an effect on antioxidant levels, during the 2007 annual meeting of the American Society for Horticultural Science, a team from Colorado State University reported that growing methods were responsible for at least a third of the increase in antioxidants in the melons they were testing and that regardless of the genetics, organic management increased both Vitamin C and antioxidant levels compared to conventional.

Paper of the Year

Dozens of important scientific studies were published in 2007 on the consumer health benefits of organic food and farming, but one stands out as extraordinarily significant because of the scope of its implications. It contains solid evidence in support of a causal relationship between organic farming, gradual soil quality improvement, enhanced nutrient density and overall food quality and safety.



Organic tomatoes have up to double the antioxidants compared to conventional.

UC Davis scientists have been carrying out a long-term farming systems trial comparing organic and conventional tomato production for over a decade. They have compared yields, nutrient content, production inputs and costs, impacts on soil quality and specific combinations of production practices. The most recent publication to appear from this long-term trial came out in the June 23, 2007 issue of the *Journal of Agricultural and Food Chemistry*.

The team reported a near doubling in health-promoting flavonoids in tomatoes in the organic system, compared to conventionally grown tomatoes. They also reported another, unexpected finding—the gap between the flavonoid levels in the organic versus conventional tomatoes increased steadily over time. The longer the fields were managed organically, the greater the nutrition premium. The increase in flavonoid nutrient density in the organic tomatoes continued despite cutting back significantly on the rate of compost applied to the organic plots.

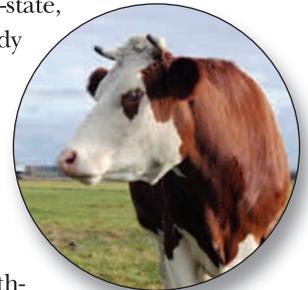
The team wondered why. They concluded that changes in nitrogen levels and plant nutrient cycling within the higher-quality soils in the organic plots were the most plausible explanation. The linkage between improved soil quality and more nutrient-dense food stands as powerful evidence in support of a basic principle of organic farming—feed the soil to better feed the plant.

Concerns Over Conventional Meats

Questions about the safety of using growth-promoting hormones in beef production have lingered for years. The Europeans banned growth hormones in 1988, but in the United States growth hormones are utilized by the vast majority of ranchers.

A team of scientists from the United States and Denmark compiled data

through the “Study for Future Families,” a five-state, multicenter study of pregnancy outcomes carried out between 1999 and 2005. They focused on the impact of a mother’s beef consumption on her



Beef from cows treated with hormones can cause impaired fertility.

adult son’s reproductive health and capabilities.

They found that sons born to mothers who were frequent beef consumers (more than seven servings per week) were three times more likely to meet the World Health Organization’s criteria for impaired fertility than sons born to moms who ate beef less regularly. The same was not true for other red meat that did not contain added hormones. The scientists concluded that exposure to steroids in conventional beef was the most plausible explanation for this study’s remarkable findings.

Other scientists have analyzed the persistence and spread of beef hormones and other animal drugs in the environment, and studies published in 2007 paint a worrisome picture. Beef feedlot hormones move via runoff and the spreading of manure into surrounding soils and into water. This can add to the growing environmental problem of excess sex hormones contributing to impaired fertility and even transgender wildlife.

Besides the dangers of hormones, there has also been some discussion that links conventional meat processing techniques to the increased incidents of *E. coli* in beef in 2007. Last year, 21 million pounds of hamburger from Topps was recalled because of *E. coli* contamination. Possible explanations include weather stress, mixing contaminated distillers grain from ethanol production plants into cattle

feed rations, and most worrisome, a genetic adaptation of the bacteria to become more virulent or resistant to the chemicals used to wash conventional beef carcasses in slaughter plants.

Powerful New Evidence on Agricultural Antibiotic Use

Agricultural use of antibiotics at subtherapeutic levels to promote animal growth and prevent disease has been controversial for over 40 years. Until the late 1990s, the animal drug industry and livestock organizations were able to beat back efforts by medical doctors and public health agencies to link agricultural antibiotic use to the emergence and spread of antibiotic-resistant bacteria causing human infections and disease.

Research by the U.S. Centers for Disease Control in the 1998-2005 period established clear causal relationships between the use of antibiotics on the farm and the emergence of newly resistant strains of bacteria that then moved from the farm into the human population. Once there, these bacteria found ways to combine with other human pathogens, triggering serious, yet avoidable, human illnesses, higher treatment costs and more serious complications.

Despite the fact that solid scientific studies have shown the use of antibiotics to have such a negative effect, little has changed on the farm and federal regulatory agencies have taken essentially no action. As a result, research continues, leading to the first-ever study exploring the presence of antibiotic resistant bacteria in workers in the broiler industry. Carried out in 2005 to 2006 and published in 2007—over fifty years after the first antibiotic was fed to broilers on a chicken farm to accelerate weight gain—this study reached several chilling conclusions.

Poultry workers had 32 times the odds of carrying gentamicin-resistant *E. coli* compared to people in the same community not working on a chicken farm. The workers also were much more likely to carry multi-drug-resistant *E. coli*. But for those who believe that agricultural use of antibiotics is, and has always been safe, this study, just like the last few hundred, was not good enough, or thorough enough or broadly applicable, and hence is not sufficient to support changes in drug use on the farm, or public policies regulating such use.

New Insight on Pesticide Risks

The best known and most often-repeated piece of conventional toxicological wisdom—"the dose makes the poison"—officially crashed and burned in 2007, the victim of a growing body of innovative research on endocrine disruptors and the developmental impacts of a range of toxic chemicals, including pesticides.

Recent studies have found that the timing of exposures to chemicals, viruses and bacteria, or imbalances in nutrient intake, play a major role in the consequences of such exposures and imbalances, and so it is not just the dose that makes the poison, but the dose, and when and how it is delivered to a particular organism.

Pregnant women, the child (or children) they are carrying, and infants and children are by far the most vulnerable following exposure to the majority of chemicals. The developing baby is exposed to everything mom is exposed to, but lacks an adult woman's ability to detoxify chemicals and repair the damage they cause at the cellular level. Their rapid growth is orchestrated by dozens of regulatory proteins that must be



EPA has determined that carcinogens are, on average, 10 times more potent for babies than for adults, and in some cases up to 65 times more potent.

manufactured by the body at just the right time, in just the right amount. Anything that blocks their production and action, or mimics them, can steer a baby's development off course, with lifelong consequences. As one example of this, the EPA has determined that carcinogens are, on average, 10 times more potent for babies than for adults, and in some cases up to 65 times more potent.

For children, milk is a major part of their diet, but drinking conventional milk may have serious effects on their health. The USDA tested 788 samples of milk in 2005 and found, on average, residues of more than 2.5 pesticides per sample. Most worrisome are residues of synthetic pyrethroid insecticides and other developmental toxins in nearly half of the samples of conventional milk.

Pesticides and Farm Workers.

Besides the residues on our food, pesticides are especially dangerous to the children whose families work on conventional farms. A study, published in *Environmental Health Perspectives*, looked at 60 farm workers' children ages 1 to 6 and found 14 different pesticides in their urine, including seven organophosphate (OP) insecticides—dangerous chemicals known to impair the development of the nervous system and brain. Almost 90 percent of the 60 children had three or more pesticides detected, one-third had five or more, and only one child had none. On average, four pesticides were found in each child's urine, including about 2.5 OPs.

It is discouraging that in 2004, eight years after passage of the 1996 Food Quality Protection Act, farm workers' children were still exposed to multiple, dangerous OP insecticides. Each acre that shifts from conventional to organic production means one less acre sprayed with toxic insecticides, and a safer environment for farm workers and their families, as

well as other people and species living near and around sprayed fields.

Advanced Glycosylation End Products (AGEs)

AGEs are the most under-reported, important food safety story of the year. Advanced glycosylation end products are created when bonds are formed between nutrients and sugars through non-enzymatic means, often with help from high temperatures and/or pressures. Recent studies have shown a wide array of damaging impacts when diets contain high levels of AGEs, including accelerated aging and collagen breakdown as well as an increase in cardiovascular complications, especially for those with diabetes. While some AGEs are formed in the body, many come from food, and scientists are researching to see which are the most damaging and what can be done to reduce levels.

In plants and people, sugars are typically bound to vitamins, antioxidants and proteins through enzymatic processes in a never-ending dance of shifting chemical bonds. A glycosylated vitamin, protein, lipid or antioxidant is one that has a sugar attached to it; when the sugar is stripped off, the lipid or nutrient is present in aglycone form and typically becomes more bioavailable.

Organic and AGEs. One of the benefits of organic farming under study by the Center is whether a greater share of the nutrients in organic fruits and vegetables are present in their aglycone form. In addition to this, some antioxidants are known to inhibit AGE formation, yet another reason why organic production could help lower the AGEs in the body. The generally lower levels of sugars in organic food could also help reduce AGE intakes. Lastly, the extraction methods allowed in organic processing of oilseed crops, and methods used to make organic fruit and veg-

etable juices may also reduce the formation of AGEs, because organically acceptable processing methods depend on lower temperatures and/or pressures.

More research is needed, and soon, to explore these and other mechanisms that show promise in reducing AGEs in food. The capacity to reduce the dietary load of AGEs may emerge as one of the most important food safety advantages of organic food, especially if the industry makes a commitment to understand where and how its production and processing technologies impact AGE levels.

Diabetes-Like Syndrome in Conventional Crops

Today, the prevalence of diabetes is nearly double that of levels a decade before. When the role of diet in diabetes and other weight-related diseases is studied, the focus is generally on excess caloric intake and increased consumption of saturated fat. Changes in the nutritional quality of food, however, are rarely, if ever, addressed. But now research is looking more closely at this issue.

Studies have shown that the metabolic dysfunction that causes diabetes arises from exposure of the body's cells to an excess of nutrients. What if essentially the same thing could happen in plants that are "over-fed" due to the use of synthetic fertilizers? It's clear that excessive nitrogen in the conventional soil leads to elevated, abnormal sugar levels and glycosylation patterns in plants. This, in turn, leads to nutrient dilution, through mechanisms described in detail in the Center's September 2007 Critical Issue Report "Still No Free Lunch" by Brian Halweil.

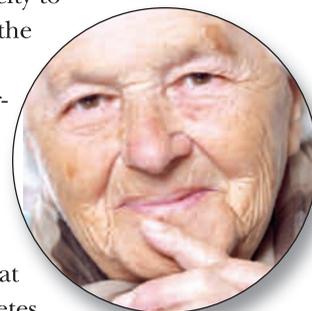
Excess nitrogen is a fact of life on virtually all conventional farms. Published research shows that 30 to 100 percent extra nitrogen is typically applied on conventional cropland. An overload of nitrogen impacts plants in many of the same ways that excess calories impact humans.

Over-amped plants grow faster and the produce harvested from them tend to be larger. Fruit size increases mostly because existing cells become, on average, larger. There also tends to be more space between larger cells, space devoid of nutrients. These physiological changes lead to nutrient dilution, and cell walls that become stretched, like a balloon. The more stretched a cell wall, the easier time pathogens have in penetrating it. A large body of research suggests that these changes in plant cells lead to elevated risk of damage from reactive oxygen species, increases in the plant's vulnerability to a range of pathogens and bacteria, nutrient dilution, less intense flavors and reduced storage stability. In short—erosion of food quality.

Too much sugar in the blood of human diabetics does many of the same things, and probably for some of the same reasons. The long-term impacts on infants and children of elevated sugars in common foods, coupled with reduced nutrient density and flavor, may be both qualitatively and quantitatively distinct from impacts on adults.

These are among the reasons why the Center has raised two novel questions. Do conventionally grown plants suffer from a diabetes-like syndrome? And, are there human health implications when people consume food harvested from plants afflicted with such a syndrome?

We are convinced that scientists need to look more deeply at qualitative changes in food, especially changes linked to, or triggered by changes in sugar



Could conventional farming methods contribute to accelerated aging and chronic illness such as diabetes?

levels and forms. A deeper look using the powerful, modern tools accessible to biomedical researchers, might identify relatively simple ways to help people stabilize their blood sugars and weight, short of major (and unlikely) lifestyle changes and drug interventions. Consumption of nutrient-dense organic produce clearly is one simple intervention which deserves a fresh look as part of a truly integrated approach to health promotion.

Looking Ahead

Science is a powerful force, for good and sometimes evil. It drove the technological changes that created today's food system. Recently, science has begun looking under long-forbidden rocks. A new generation of scientists are conducting rigorous, world class research in the hope of connecting dots between how food is

The Organic Center's Goals for 2008: Bridging Research and Consumer Awareness

From aging to heart health, more and more research is coming out that presents huge potential to create strong scientific links between better health and organic foods. The Organic Center's goal this year is to start bringing all this research together and presenting it in a way that consumers can easily see a clear, direct benefit of eating organic foods. Here are the Center's goals:

1. Identify why and how organic farming systems may affect aging in humans. Investigate how chemical agriculture may alter the sugar levels and forms in plants, accelerating the aging process in those who eat them, and whether organic food can play a role in lessening the frequency and/or severity of signs of aging, such as diabetes and its complications. Explore whether heavily fertilized plants can suffer from a diabetes-like syndrome, and the degree to which organic farming protects plants from such a syndrome.

2. Solidify the strong and growing evidence on the positive impact of organic farming on nutrient density and flavor. Explain why nutrient content and flavor are governed by many of the same factors and are typically elevated in organic systems. Increase the percent of consumers citing the nutritional benefits of organic fruits and vegetables as the number one reason for purchasing organic food to equal the share now reporting pesticide residues as the major reason for buying organic.

3. For women of child-bearing age and children through adolescence, explain why and how organic farming and food processing, and organic food, reduces markedly the risk of developmental problems involving a child's neurological, immune and reproductive systems, and can lessen the frequency of common health and behavioral problems from eczema to food allergies, and asthma to ADHD.



grown, food processing methods, and how food and dietary choices impact us and the health of the planet.

New science is essential to learn how to change agricultural production and food processing technology to better promote human health and environmental quality. We hope that organic farmers and the organic food industry will be among those insisting that rigorous, independent science be carried out. That is the first step. Then, the organic community must also be among the first to push the envelope toward safer, higher quality foods when new science points the way toward those vital goals. The growth and prosperity of the organic industry depends on it, as does so much more. □

Charles Benbrook, PhD, is the chief scientist at The Organic Center. He has worked in Washington, D.C. on agricultural policy, science and regulatory issues and was the executive director of the Board on



Agriculture of the National Academy of Sciences. You can reach him at cbenbrook@organic-center.org.

Dr. Alan Greene, MD, is a clinical professor of pediatrics at Stanford University



School of Medicine and the chairman of the board for The Organic Center. He sits on the Advisory Board of Healthy Child Healthy

World and is a founding partner of the Collaborative on Health and the Environment. He is also the author of "Raising Baby Green" and "From First Kicks to First Steps." You can reach him at alan@drgreene.com.