The Organic Center www.organic-center.org
Critical Issue Report: Still No Free Lunch

Still No Free Lunch:
Nutrient levels in U.S. food supply eroded by pursuit of high yields

by Brian Halweil

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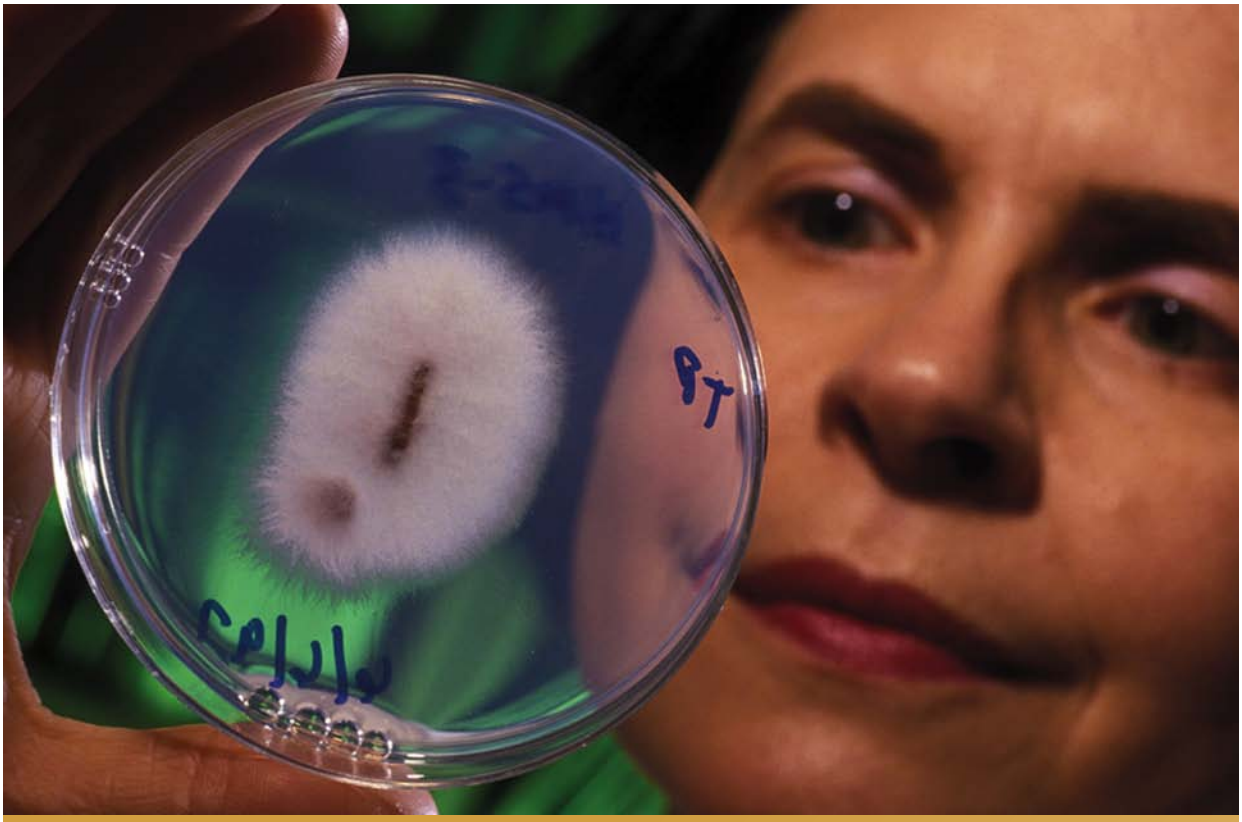


"A knowledge of the chemical composition of foods is the first essential in dietary treatment of disease or in any quantitative study of human nutrition."

R.A. McCance and E.M. Widdowson,

The Composition of Foods, 1940

Dr. Alan Greene is the Founder of www.DrGreene.com and the Chief Medical Officer of A.D.A.M., a leading publisher of interactive health information. He teaches medical students and pediatric residents at the Stanford University School of Medicine, and is an Attending Physician at Stanford University's Lucile Packard Children's Hospital.

Foreword

The Organic Center's second "State of Science Review" came out in early 2005 and focused on antioxidant levels in organic and conventional foods. We found that, on average, organic food contained 30 percent higher levels of antioxidants based on then-published studies.

This surprising finding triggered new research by the Center into the roots of food quality. We sponsored a symposium on the topic at the 2006 meeting of the American Association for the Advancement of Science, and asked Brian Halweil of the Worldwatch Institute to write a report on the impact of rising crop yields on food nutrient density. We are pleased to release Brian's report and are confident it will help focus the attention of agricultural scientists, farmers, private industry and government on the importance of reversing the slow, incremental erosion in the nutrient density of many staple crops.

Why is this report so important and timely? Many of our most common and costly health problems are diet related. America's public health is suffering because of the way we grow food, the chemicals we apply to crops, the drugs we administer to farm animals, our excessive reliance on processing, and too much added fat and sugar in way too many foods. In the years ahead, progress in reducing the frequency and severity of many diseases will depend increasingly on improving food nutritional quality and patterns of dietary choice, rather than simply an ever-widening dependence on drug-based therapies and surgery. A renewed focus on increasing nutrient density in step with crop yields is long overdue and a step in the right direction.

Dr. Alan Greene
Vice-Chair of the Board
The Organic Center

The Organic Center

Executive Summary

Farmers have doubled or tripled the yield of most major grains, fruits and vegetables over the last half-century. They have done so by capitalizing on the work of plant scientists, crop breeders and companies manufacturing a wide range of inputs—from fertilizer to water, pesticides, sophisticated machinery and diesel fuel.

Yield increases per acre have come predominantly from two sources—growing more plants on a given acre, and harvesting more food or animal feed per plant in a given field. In some crops like corn, most of the yield increase has come from denser plantings, while in other crops, the dominant route to higher yields has been harvesting more food per plant, tree, or vine.

But American agriculture's single-minded focus on increasing yields over the last half-century created a blind spot where incremental erosion in the nutritional quality of our food has occurred. This erosion, modest in some crops but significant in others for some nutrients, has gone largely unnoticed by scientists, farmers, government and consumers.

The Evidence

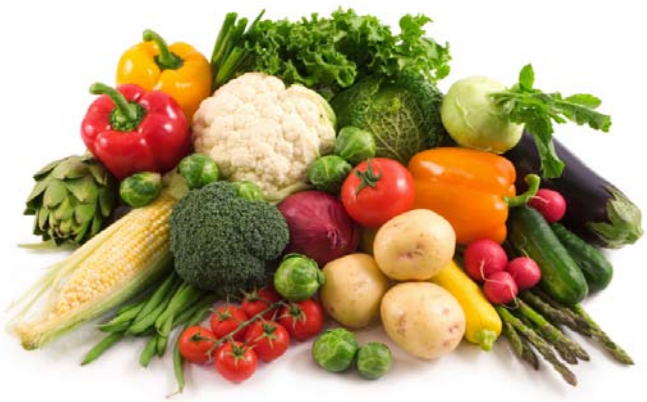
Government data from both America and the United Kingdom have shown that the concentration of a range of essential nutrients in the food supply has declined in the last few decades, with double-digit percentage declines of iron, zinc, calcium, selenium and other essential nutrients across a wide range of common foods. As a consequence, the same-size serving of sweet corn or potatoes, or a slice of whole wheat bread, delivers less iron, zinc and calcium.

Fewer nutrients per serving translate into less nutrition per calorie consumed. This erosion in the biological value of food impacts consumers in much the same way as monetary inflation; that is, we have more food, but it's worth less in terms of nutritional value.

The accuracy and reliability of historical data-sets on food nutrient composition have been questioned, since testing methods have changed so much over the years. Contemporary experiments, though, have confirmed that the nutrient decline observed in historical data-sets is real.

These experiments entail planting modern and historical crop varieties—or high- and low-yield varieties of assorted crops—side-by-side, using comparable agronomic practices (e.g., tillage, planting method, sources and levels of nutrients, harvest method and timing). Studies with wheat, corn and broccoli have found that modern, high-yielding varieties generally have lower concentrations of nutrients than older, typically lower-yielding varieties.

The tradeoff between yield and nutrient level seems to be widespread across crops and regions, as plants partition their limited energy between different goals. Substantial data show that in corn, wheat and soybeans, the higher the yield, the lower the protein and oil content. The higher tomato yields (in terms of harvest weight), the lower the concentration of vitamin C, levels of lycopene (the key antioxidant that makes tomatoes red), and beta-carotene (a vitamin A precursor). High-production dairy cows produce milk that is less concentrated with fat, protein and other nutrition-enhancing components, and are also more vulnerable to a range of metabolic diseases, infections and reproductive problems.



Given these negative consequences linked to increasing yields and production levels, why the continuing, nearly universal focus on increasing yields and production, regardless of the associated costs?

Crop breeders have focused predominantly on developing varieties that produce higher yields because that is what farmers have asked for, and what farm commodity markets, federal farm policy, and those funding agricultural research and extension programs have rewarded. In fact, according to several scientists, there are few systematic breeding efforts currently underway in the United States with the goal of raising the nutrient content of major foods. Breeders are unlikely to change without incentives. The same is true among animal breeders, scientists and livestock farmers.

Agronomic practices have worked hand-in-hand with plant breeding in setting the stage for this nutrient decline. Together, the tactics farmers use to increase yields—including close plant spacing and the widespread use of chemical fertilizers, irrigation and pesticides—tend to create big plants that grow fast, but do not absorb a comparable quantity of many soil nutrients. The plants are dependent on highly soluble, readily available sources of nutrients applied by the farmers, as opposed to those distributed through each acre's layer of topsoil. In fact, recent studies have shown that crops grown in poor quality, low organic matter soil sometimes have higher rates of root disease, and can struggle to absorb nutrients even when the nutrients are present at high levels in the soil profile.

No Free Lunch

Think of this relationship between yield and nutritional quality as farming's equivalent of "no free lunch." That is, higher yields, while desirable, may come with the hidden cost of lower nutritional quality, and in some cases, heightened risk of food safety and animal health problems.

As breeders have programmed plants to produce larger tomatoes, shorter-statured wheat with bigger grain heads, and corn that can tolerate closer spacing in the field, these plants have devoted less energy to other factors, like sinking deep roots and generating health-promoting compounds known as phytochemicals, many of which are antioxidants and vitamins.

The unintentional and largely unnoticed slippage in nutrient density has been accepted as a price of progress in boosting yields. After all, more total nutrients are harvested from a field of corn producing twice the yield, even if it means 20 percent less protein or iron per bushel. In addition, fortification of food with vitamins and minerals has been available, and used, to address blatant deficiencies in nutrient intake.

Many farmers now plant 30,000 or more corn seeds per acre, about three times the planting density common in the 1940's. The volume of corn grain harvested per corn plant has changed little in the last half-century.

Further erosion in nutrient density should be avoided for several reasons. Americans need to consume foods that deliver more nutrients per calorie consumed. Science has yet to identify, much less understand, the nutritional benefits linked to thousands of phytochemicals produced by plants. Many epidemiological studies have concluded that there are likely many beneficial nutrients in fruits and vegetables that we do not know about.

Plus, the relative levels, or ratios of nutrients in food, may also play important roles in human nutrition and health promotion. And what we surely do not need are staple crops delivering more sugar and starch per serving, and lower levels of vitamins, minerals and antioxidants.

Turning the Corner

Recent research shows that existing varieties of a given crop, whether pumpkins or peas or plums, vary widely in terms of their vitamin and mineral content. And this variability is inheritable, and it doesn't necessarily interfere with crop yields. So it should be possible for crop breeders to favor these varieties or use them in breeding efforts to

make our food more nutritious, with only modest impact on average yields.

Moreover, given that part of nutrient decline has resulted from farmers pushing crops towards maximum yields, changing certain farming strategies should help reverse the decline. For instance, although organic farming results in lower yields in many cases, studies show that it also tends to produce crops with higher concentrations of micronutrients, phytochemicals and other health-promoting compounds. The increases range from a few percent to sometimes 20 percent or more for certain minerals, and on average, about 30 percent in the case of antioxidants.

A recent study documented a near-doubling in the levels of two antioxidants in organic tomatoes.

Some studies have reported even more dramatic differences in concentrations of specific phytochemicals—for example, nearly twice as much of two common antioxidants in organic tomatoes compared to conventional tomatoes. Organic forms of fertilizer, like manure or cover crops that offer more balanced mixes of nutrients and release the nutrients more gradually, encourage plants to develop more robust root systems that more aggressively absorb nutrients. At the same time, for a wide range of fruits, vegetables and grains, reducing pesticide use has been shown to boost phytochemical content, sometimes dramatically.

Might this general nutritional superiority of organic produce help justify the premium that consumers typically pay for organic food, or government policies to encourage a shift towards organic practices? Clearly, advantages linked to organic management will vary depending on the crop, soil quality and growing conditions, as well as on the technologies, inputs and systems in use on nearby conventional farms growing the same crop.

There will be some cases, usually linked to weather conditions, and pest levels and management, where conventional crops have higher nutritional quality than nearby organic crops. And, as organic farmers find ways to push yields close to the levels on conventional farms, the nutritional advantage of organic systems may narrow, and even disappear in some cases. Research is needed to identify farming systems and plant genetic innovations capable of increasing the nutrient content of foods without significant impacts on yields.

Significant erosion in the nutritional quality of the American diet rests on declining nutrient density in staple crops, coupled with increasing consumption of largely “empty” calories (“empty” in the sense that some foods contain high levels of added sugar and fat, and deliver very few nutrients per calorie consumed). Compared to half a century ago—when crop yields first began to climb dramatically—we are eating fewer nutrient-rich foods like fresh fruits and vegetables, and whole grains, and more highly processed foods. Contemporary epidemics of obesity and diabetes are among the direct consequences. This is why the U.S. government has placed so much emphasis on doubling average per capita consumption of fresh fruits and vegetables.

Improving the nutritional quality of these foods, and indeed all crops, will be an important part of addressing larger nutritional and health problems, particularly as the baby-boom generation ages. Cost-effective health promotion and disease prevention will likely depend more and more on improving dietary choices, and the nutritional quality of the foods we choose to eat, rather than on ever-greater dependence on drug-based therapies and invasive surgical procedures.

The good news is that farmers, crop breeders and agricultural scientists will almost certainly be as successful in increasing nutrient density, as they have been in raising yields, once they shift their priorities. But for this to happen, our clear-cut need for food that delivers more nutrition per calorie consumed must drive the system on equal footing with the pursuit of ever-higher yields. It’s that simple, yet also exceedingly complex.

Lessons Learned

Despite impressive increases in crop yields around the world, much of humanity remains malnourished, including the 3 billion people in poorer nations who suffer from caloric and micronutrient deficiencies, and those in wealthy nations who consume too many calories on a daily basis, yet inadequate levels of several essential nutrients.

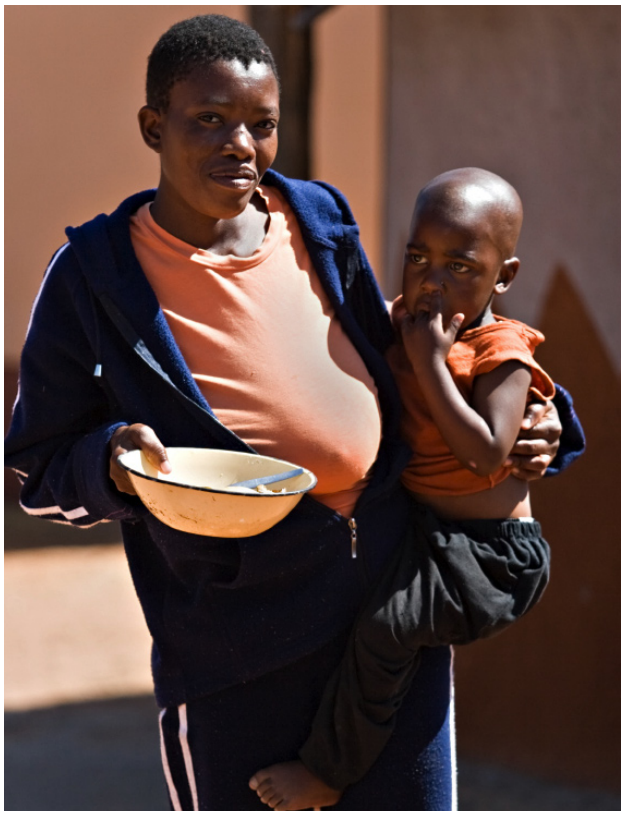
The single-minded focus by agricultural scientists and farmers on pushing plants and animals towards higher yields and levels of production has produced food with lower nutrient concentrations. In some cases, it has also created new food safety challenges, and made plants and animals more vulnerable to pests, diseases and reproductive problems.

Nutrient decline stems, in part, from the fact that high-yield crops devote energy to producing large fruit, grains or seeds, and put less emphasis on absorbing micronutrients. Faster growing plants that produce larger fruits and vegetables tend to dilute nutrient concentrations, a phenomenon labeled the “dilution effect” by scientists in the early 1980s.

High levels of readily available nitrogen tend to reduce nutrient density and the intensity of flavors, and sometimes make crops more vulnerable to pests. Nutrients in compost, manure, cover crops and other soil amendments tend to be released more slowly in step with crop needs, and often help to boost crop nutrient levels, the efficiency of nutrient uptake, and flavor profiles.

The large amounts of organic matter returned to the soil in organic farming systems encourage healthier, more robust roots, higher levels of available micronutrients, water infiltration and retention, and below-ground microbial activity that can help increase crop nutrient density.

A comprehensive strategy to improve public health by increasing nutrient levels in the food supply should include R+D investments and economic incentives focused on raising crops with greater nutrient density. Fortunately, farmers and scientists will likely excel in pursuit of this goal, as their focus shifts from maximizing yields at any cost, to maximizing yields and nutrient density.



Hunger still impacts about three billion people around the world, like this mother in the Kalahari desert. For the chronically malnourished, an increase in caloric consumption is essential to improve well-being. As people reach sufficient caloric intakes to maintain health, assuring proper balance across nutrients in the diet becomes the next hurdle that must be crossed for sustained progress toward food security and improved human health.