COMPREHENSIVE REVIEWS IN FOOD SCIENCE AND FOOD SAFETY

A Review of the Nutrition Claims Made by Proponents of Organic Food

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ABSTRACT: Health-conscious consumers have an interest in knowing if the extra money they spend on organic food is justified. The organic food industry, therefore, has a large financial interest in convincing the public that the food they sell is healthier, tastier, and better for the environment. One area that the industry has concentrated on is the supposed nutritional superiority of their product. The importance of this area to the organic food industry can be seen by the vehemence in which it has attacked and tried to discredit a recent, widely circulated report submitted to the British government that found no scientific evidence for claims that organic food is nutritionally superior to conventional food. Two nongovernment organizations, the Soil Assn. in the United Kingdom and the Organic Center in the United States have been heavily involved in the promotion of organic food. Both of these organizations exert a great deal of influence with the media, and hence with consumers, in both countries. An examination of some of their actions will be included in this article.

Introduction

Dating back to 1924, numerous studies dealing with the nutritive advantages, or lack thereof, of organic food have been published. These studies have been reviewed by a number of writers. Woese and others (1997), after examining about 150 publications, concluded that "with regard to all other desirable nutritional values. . . ..no major differences were observed" between organically and conventionally grown vegetables. Worthington (2001) reviewed 41 publications and noted increased vitamin C, magnesium, iron, and phosphorus, as well as lower nitrate content in organic vegetables but found no differences between organic and conventional vegetables for any other minerals or vitamins. Bourn and Prescott (2002) looked at 49 publications and found that "with the possible exception of nitrate content, there is no strong evidence that organic and conventional foods differ in concentrations of various nutrients." They also reported that organic food did not taste any better than conventional food in objective taste tests. Magkos and others (2003) concluded that "a balanced diet rich in fruits and vegetables, and adequate in foods from the other groups, is unequivocally able to maintain and improve health, regardless of its organic or conventional origin." A recent research publication (Kristensen and others 2008) concluded that organic food did not contain any more trace elements than conventional food. A literature review (Lairon 2009) commissioned by the French Agency for Food Safety (AFSSA) reported no differences in mineral content between organic and conventional fruits. A "trend" was observed for higher levels of iron and manganese in some organic vegetables as well as much lower levels (28% to 86%) of nitrate in many, but not all, organic vegetables.

In recent years, the emphasis has shifted to antioxidants. It is widely believed that antioxidant chemicals may be important in the control of free radicals, chemical species that we produce as part of normal metabolic processes which may be responsible for initiation of certain cancers as well as contributing to atherosclerosis. There are several types of antioxidants found in food: beta-carotene, lycopene, vitamin C, vitamin E; phenolic acids such as caffeic acid and flavonoids such as quercetin. Phenolic acids and flavonoids are many times measured together and the results are referred to as total phenols. It must be pointed out that these chemicals may operate by mechanisms different from free radical control; nor is there any definitive proof that they actually contribute to human health. But many scientists do believe that these chemicals are, in fact, healthful, a view apparently shared by most of the general public. So it behooves merchandisers of organic food to claim that there are more antioxidants in organic food than in conventional foods. An attractive theory for the presence of higher concentrations of certain antioxidants in food crops is that they are produced by the plant to ward off insect and fungal attack. Since conventional crops are protected by pesticides, they do not need to synthesize these materials. The problem with this theory is that organic farmers use "natural" pesticides, copper sulfate, and physical methods to suppress insect and fungal activity. Another problem with the theory is that some pesticides increase secondary metabolite formation while others decrease it (Sweeney and Marsh 1971; Rouchaud and others 1983; Daniel and others 1999). Concentrations of the flavonoids, quercetin and kaempferol, were increased after foliar

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treatments of benzothiazole on strawberries (Anttonen and others 2003). Chitosan, a pesticide that can be used in both organic and conventional farming has a powerful effect on flavonoid content (Ren and others 2001).

A 2nd theory holds that the higher availability of nitrogen in soils treated with synthetic fertilizer leads to production of nitrogen-containing metabolites at the expense of carbon-containing metabolites such as the phenolic antioxidants (Brandt and Molgaard 2001). Several published articles have lent some credence to this theory (Leser and Tretter 2005; Toor and others 2006; Nguyen and Niemeyer 2008).

The Soil Assn.

The Soil Assn. is a British charity (roughly the same as a not-for-profit organization in the United States) dedicated to the growth of the organic food industry. According to the latest available figures, the association derives its annual income, about $31M from grants, certification of organic farms, membership dues, sales of agricultural reports, and donations. More than one-third of its income is derived from certifying organic farms. The association was founded in 1946 by Lady Eve Balfour who had become a convert to organic farming. She started a 30-y experiment at her farm at Haughey to prove the nutritional superiority of organic food. Experimental results, however, failed to provide any evidence for this hypothesis (Shorrocks 2007). Despite that setback, the association has, over the years, claimed that organic food is nutritionally superior to conventional food.

The current policy director of the association is Lord Peter Melchett, a man with an interesting history (Sourcewatch Encyclopedia). He is the owner of an 890-acre organic farm in the United Kingdom and served as Executive Director of Greenpeace UK between 1989 and 2000. During that period, Greenpeace was successful in preventing the introduction of genetically modified foods (which they labeled "Frankenfoods") in the United Kingdom. Melchett is the grandson of the founder of Imperial Chemicals Industries (ICI) and is the son of the founder of the British Steel Corp. In 1999, Lord Melchett was arrested for trespassing and destroying crops on a farm where genetically modified crops were being experimentally grown. He was found not guilty by convincing the jurors (who apparently did not need much convincing) he feared that pollen from the GM crops would "contaminate" the crops on his own farm (Waugh 2000).

A Great Day for Lord Melchett

October 30, 2007, was a great day for Lord Melchett. For the past few days, the major London newspapers had carried stories about new discoveries proving the nutritional superiority of organic food. These results had been announced by Dr. Carlo Leifert, Professor of Ecological Agriculture at the Univ. of Newcastle and the head of the Tesco Centre for Organic Agriculture which he set up in 2001 with an $870000 investment from Tesco, the largest seller of organic food in the United Kingdom. Dr. Leifert also headed the Quality Low Input Food (QLIF) Project, a 4-y, $25 million project funded by the European Union that "aims to improve quality, ensure safety, and reduce cost along the organic and low input food supply chains through research, dissemination and training activities" (Niggli and Leifert 2007). The project included scientists from 33 research institutions, companies, and universities throughout Europe.

According to information supplied by Dr. Leifert, organic fruits and vegetables were grown alongside conventional produce on a 725-acre experimental farm near Newcastle Univ. and their nutritional qualities were compared. Professor Leifert said that the organic produce contained "up to 40% more beneficial compounds in vegetable crops and up to 90% more in milk" (Ungoed-Thomas 2007). High levels of minerals such as iron and zinc were said to be found in organic produce. Leifert said that moving to organic food was like "eating an extra portion of fruit and vegetables every day" and implied that conventional produce was responsible for obesity and heart disease. He told the British Broadcasting Co. (BBC 2007) that the study, whose results were "due to be published over the next 12 mo," showed "more of certain nutritionally desirable compounds and less of the baddies in organic foods," but "the study showed some variations," the nature of which he did not explain.

The U.K. media were ecstatic. "Eat your words, all who scoff at organic food" headlined *The Times* (Ungoed-Thomas 2007); "Organic food is healthier and safer, 4-y EU investigation shows," wrote *The Independent* (Dugan 2007); "Organic produce 'better for you'" said the *BBC* (BBC 2007). *The Telegraph* chimed in with "Organic food better than ordinary produce" (Cockcroft 2007) while *The Guardian* headlined a more subdued "Organic food is healthier: study" (Sample 2007). None of the media reporters asked Leifert for independent proof of these findings, which he claimed would be published within the next 12 mo (by November 1, 2008).

The fact that Leifert had no data to back up his claims did not appear to bother the media reporters, who were much more interested in the running battle between the U.K. government's Food Standards Agency (FSA) and the Soil Assn., intimating that the FSA would soon have to recognize that it was wrong. In an opinion piece that appeared in *The Guardian* on October 30, Melchett (2007) badgered the FSA and its chief scientist, Andrew Wadge, to admit that organic food was better. (The FSA was set up to ensure food safety and to protect consumer interest and has responsibilities pretty much the same as those of the Food and Drug Administration in the United States in the regulation of food and food additives. Since 2000, the FSA has resisted the attempts of organic food proponents to declare organic food nutritionally superior to conventional food.) By 2007, however, the FSA had commissioned an independent group of scientists to study and evaluate the relevant literature dealing with nutritional differences between the 2 agricultural methods.

A Press Release from the Soil Assn.—October 30, 2007

On the same day, the Soil Assn. weighed in with a demand that the FSA "publicly acknowledge the nutritional benefits of organic food" (Soil Assn. 2007), a demand that was based on 5 points that essentially summarized its case:

1. a 2001 report written by an "independent nutritionist" who "reviewed over 400 scientific papers" and found "indicative evidence" for higher levels of "vitamin C, minerals, and trace elements" (Heaton 2001a).
2. three presentations by French and Polish scientists at a QLIF Symposium held at the Univ. of Hohenheim in Germany, March 20–23, 2007. According to the U.K. press, higher concentrations of antioxidants were found in organic peaches, tomatoes, and apples.
3. a peer-reviewed article written by Univ. of California scientists (Amodio and others 2007) that organic kiwis had more vitamin C and total phenols than conventional kiwis.
4. research at several dairy farms that found higher levels of "beneficial" vitamins, antioxidants, and omega-3 fatty acids in the milk of cows that were raised on grass and clover.
5. the results from the QLIF study announced by Dr. Leifert just a day or two earlier that were going to be published in peer-reviewed journals during the next 12 mo.

A Closer Look at the Soil Assn. October 30, 2007, Press Release

The 2001 report

In 2000, Sir John Krebs, at that time Head of the U.K. Food Standards Agency, said that organic food was "no safer or more nutritious than conventionally grown food." Sir John went on to say that consumers were "not getting value" for their money "if they think they're buying food with more nutritional quality or extra safety" (BBC 2000). To counter the damage done by the FSA pronouncement, the Soil Assn. commissioned a report (Heaton 2001a) titled "Organic Farming, Food Quality, and Human Health: a review of the Evidence." An August 6th press release (no longer available on the Internet) accompanied the report and claimed that "over 400 published papers" were examined and that "on average" organic crops "are not only higher in vitamin C and essential minerals," but also higher in chemicals that "are often beneficial in the treatment of cancer." The major U.K. newspapers treated the report favorably, using only the Soil Assn. August 6th press release for information. An information sheet based on the 2001 report (Soil Assn. 2002) claimed that "alternative cancer therapies have achieved good results relying on the exclusive consumption of organic food." One would think that Heaton (whose record does not indicate a degree in nutrition or in any other scientific discipline) would spend more than 105 words (see page 48 of the report) on a subject of such import to human well-being.

Had the reporters read the actual report instead of relying on the Soil Assn. for analysis of its own publication, they would have found that of the over 400 published papers only 99 compared organic to conventional food and 70 of these were rejected by the author because they did not fit his self-imposed criteria for valid comparisons or for proper organic certification. Of the 29 remaining studies, only 16 had been published in peer-reviewed journals. Five publications dealing with antioxidant differences were found, but only 2 of them were published in scientific journals and the reported differences were not statistically significant.

So what had been touted as a thorough review of the literature turned out to be a review of only 16 articles. And even in these precious few studies, the results were inconsistent. Combining all reports that fit the author's criteria for consideration revealed that organic produce had higher levels of minerals in only 7 out of 14 studies and higher levels of vitamin C in only 7 out of 13 studies (Heaton 2001b).

Reports from the QLIF symposium

On March 28, 2007, a newspaper article (*Daily Mail* 2007) reported that studies in several European countries had shown that organic tomatoes, apples, and peaches contained greater concentrations of nutrients "said to protect the body against heart attacks and cancer-causing chemicals" than their conventional counterparts. Later that week, *The Independent* (Herbert 2007) reported new research that organically grown peaches and apples contained higher levels of chemicals that "protect against heart attacks and cancer" than conventional fruits. Both newspaper articles implied that U.K. government officials were wrong in not admitting how healthful organic food was and both articles contained errors which indicated that neither newspaper reporter had ever attended the symposium at which these results were presented or had even spoken to the scientists who made the presentations.

Reading the summaries written by the scientists, however, provides more accurate accounts of the symposium. For example, one QLIF investigator wrote that organic peaches grown in 2004 had 46% higher total phenol content than conventional peaches, but there were "no significant differences in 2005" (Fauriel and others 2007). If you do a little simple algebra with the data provided by the investigators, you can calculate that conventional peaches contained 30% more total phenolics than the organic peaches in 2005. This information is available on the Internet, but not in any of the newspaper stories, Soil Assn. communications, or the 2008 Organic Center report (which will be discussed in more detail later).

A 2nd lecture compared organic and conventionally grown tomatoes cultivated at different farms in Poland. But the distance (36 miles) between the farms and the fact that the organic tomatoes were grown in a soil of a different type than the soil in which the conventional tomatoes were grown made meaningful interpretation of the results impossible. A graduate student involved with this study "found different levels of the nutritional compounds in every year of her studies" and "concluded that organic production methods did not guarantee a higher-quality product" (Hallman and Rembialkowska 2007).

A 3rd presentation reported higher antioxidant capacity in 3 different varieties of organic apples, but no statistical data were given, making the data useless. Some of the data made no sense. For example, total polyphenol content, an important factor in antioxidant capacity, was not significantly higher in the organic than in the conventional apples.

Almost 3 y have now passed since these 3 presentations were made but none of them has ever been published in a peer-reviewed scientific journal.

Comparison between organic and conventional kiwis

The Univ. of California investigators (Amodio and others 2007) made 2 serious errors. First, the assay they used measured not only total phenols but also vitamin C. To obtain correct values for the phenols one must independently determine vitamin C content and then subtract it from the total phenols plus vitamin C value (Asami and others 2003). The Amodio group did not do so and came up with too high a value for organic kiwi total phenol content. Second, total phenol concentrations are usually higher in the peel of a fruit than in the flesh. In this experiment, the organic kiwi peels were 35% thicker than the peels from the conventional kiwis, suggesting that most, if not all, of the antioxidant increase observed in the organic kiwis were in the peel. Since kiwi peels are inedible, it would have been more meaningful to measure only the edible portions of the kiwi.

Omega-3 fatty acids

Research published between 2003 and 2006 (Bergamo and others 2003; Dewhurst and others 2003; Ellis and others 2006) reported increased (about 64% to 71%) amounts of an omega-3 fatty acid, alpha-linolenic acid (ALA, CAS nr 463-40-1), in the milk of cows that had grazed on red clover and grass as opposed to those cows that were fed corn and hay. Omega-3 fatty acids have had a good press in recent years and there is some evidence that 2 of these acids, eicosapentenoic acid (EPA, CAS nr 1553-41-9) and docosahexaenoic acid (DHA, CAS nr 6217-54-5), found in salmon and tuna fish, may be helpful in preventing cancer and heart disease. ALA is also an omega-3 fatty acid, but is not the same as EPA or DHA because it contains fewer carbon atoms. An epidemiological study has found that while EPA and DHA may reduce the risk of advanced prostate cancer, ALA may increase that risk (Leitzmann and others 2004). True, ALA is converted to EPA and DHA in humans, but the conversion is very low (about 8%). In any event, a huge ALA increase in cows is meaningless because ALA is found in very small amounts in milk to begin with and increasing that small amount by 71% will not result in any appreciable health benefit. For example, nutritionists recommend that we eat 2 3-ounce portions of salmon per week. If we preferred instead to get our EPA and DHA from conventional milk, we

would have to drink 185 quarts of conventional milk every week. Drinking organic milk would cut our weekly intake to 110 quarts. But the pro-organic folks were undaunted.

Sally Bagnal of the United Kingdom's Organic Milk Suppliers Cooperative called on the FSA to "start recommending organic milk as part of a healthy diet." Kathryn Ellis, a Univ. of Glasgow scientist who was the lead author on one of the studies, published an open letter signed by 13 other scientists requesting the FSA to change its stance on organic milk and "recognize that there are differences that exist between organic and homorganic milk" (Ellis 2006).

Another article on this subject was published later by scientists from Newcastle Univ. and the Danish Inst. for Agricultural Science (Butler and others 2008). Large increases in contents of vitamin E (33%), beta-carotene (30%), lutein (67%), zeaxanthin (45%) conjugated linoleic acid (60%), and the omega-3 fatty acid, ALA (39%) were found in milk from cows that had been raised on pasture grass and clover as compared to cows fed standard grain. Again, the U.K. media sprang into action. "Drinking organic milk may cut the risk of heart disease and cancer" was the *Daily Mail* headline (Macrae 2008). Similar reports were also published in the other major U.K. newspapers except for *The Guardian*, which apparently had caught on to the scam. An article published by the U.K. NHS (2008) explaining that it had "not been demonstrated that any type of milk protects against cancer or heart disease was totally ignored by the media. But, as pointed out by Rosen (2008a), a person would have to drink between $3\frac{1}{2}$ and 170 quarts of organic milk every day to get the currently recommended quantities for these nutrients as well as a full complement of saturated fats. There is nothing magical about the organic milk produced at the Newcastle Univ. farm—when you remove the artery-clogging saturated fats you also remove all the "beneficial" constituents.

The QLIF 4-y European Union Project "results"

By the end of 2009, it will have been more than 2 y since Dr. Leifert told reporters that peer-reviewed publications detailing the nutritional superiority of organic produce would be published within 1 y. If any of these reporters had bothered to ask just a few questions, they would have discovered, as had Dr. Todd Carroll (Carroll 2007), that there were no new data for produce! About a year later, Leifert confirmed this when he told the *Montreal Gazette* (2008) that "the data are quite clear on livestock products," but there was less evidence for the nutritional benefits of organic produce. "It's not as clear a story on the cropping side" Leifert said. And if there is still any doubt, the QLIF Workshop 1 Report QLIF (2008) stated, ". . . while there is a trend for more of the nutritionally desirable secondary metabolites (i.e., antioxidants) to be found at higher levels. . . . . some compounds were unaffected and some were increased when conventional fertilization and/or crop protection schemes were applied." In other words, when ALL the data are examined, conventional crops are just as high in beneficial nutrients, if not higher, than organic crops. And just like the report from the NHS (2008), not a word of this was published in the U.K. press.

The Empire Strikes Back

The conclusions of the scientific review commissioned by the FSA to respond to the Soil Assn. attacks were made public on July 29, 2009. According to Dr. Alan Dangour, a senior lecturer in nutrition at the London School of Hygiene and Tropical Medicine, he and his research group found "no evidence of a difference in nutrient quality between organically and conventionally produced foodstuffs." Dangour laid out his results in a respected, peer-reviewed publication and not to the newspapers, for comment and criticism (Dangour and others 2009)

Criticism was not long in coming. Leading the charge was the Soil Assn. Their major complaint was that the study "failed to include the results" of the QLIF project and the "publication, so far, of more than 100 scientific papers" (Soil Assn. 2009). Never mind that these publications were not concerned with nutritional differences between organic and conventional produce (Carroll 2007). Goldacre (2009) wrote that almost all of these publications were "irrelevant" and the overwhelming majority of them were "unpublished conference reports." But this information had no effect whatsoever on Melchett (2009) who wrote that "The full results of the five years of EU research, presented at a conference in April, and including a positive review of nutritional differences, will be peer-reviewed and published next spring."

The Soil Assn. also complained that the Dangour study failed to consider pesticides, but Dangour was asked to look only at Soil Assn. claims about nutritional superiority. In fact, it was the Soil Assn.'s unfounded claims about nutritional superiority that led to this study in the 1st place. Lord Melchett had the chutzpah to tell the BBC that the Dangour review "rejected almost all of the existing studies of comparisons between organic and nonorganic nutritional differences," ignoring that many of those studies were of poor scientific quality, omitted important information, or found large increases of constituents that would be of no benefit to human health. Leifert, for his part, thought the "conclusions of the study were selective" (McVeigh 2009) apparently because his nonexistent data were not included.

The Organic Center Is Heard From

On this side of the Atlantic, the Organic Center has also been trying to convince us of the nutritional superiority of organic food. The Organic Center is a "not-for-profit" organization set up by the Organic Trade Assn. for the promotion and the sale of organic food, not as they claim, "to generate credible, peer reviewed scientific information and communicate the verifiable benefits of organic farming and products to society" (http://www.organic-center.org/about.mission.html.) "Not for profit" does not mean that the organization is more honest than organizations that are for profit; it just means that its profits are not taxable as long as the organization's income is derived from its stated purpose. Not-for-profit organizations can pay their employees and officers very high salaries. Charles Benbrook is an employee of the Organic Center, so it should not be expected that he has no financial interest in the promotion of organic food sales. Industrial donors to the Organic Center with contributions of at least $50000 include Aurora Organic Dairy, Horizon Organic, Organic Valley Cooperative, Silk Soy, Stonyfield Farm, White Wave, and Whole Foods Market. Individual donors of at least $50000 include Walter Robb and John Mackey, co-presidents of Whole Foods; Eugene Kahn, a General Mills vice president and founder of their subsidiary, Cascadian Farm; Mark Retzloff, founder of Horizon Dairies; and Steve Demos, president of combined operations for White Wave, Horizon Organics, and Dean Foods (http://www.organic-center.org/donors.corner.html). Most of the companies that started the organic food business are now controlled by the same large food companies we were told were poisoning us (Howard 2009).

A report published by the Organic Center (Benbrook and others 2008), claimed that organic food was 25% more nutritious than conventional food, a finding at odds with the Dangour study as well as a critique published (Rosen 2008b) by the American Council on Science and Health (ACSH). The ACSH report pointed out how Benbrook and his colleagues erroneously arrived at conclusions based on results from publications that

had not been peer-reviewed as well as from publications containing data that were not statistically significant. And, just like the Soil Assn., the Organic Center ignored results not to its liking. The Organic Center rebuttal to the ACSH report is at http://www.organiccenter.org/science.latest.php?action=view&report_id=130 and a reply to their rebuttal may be found at http://www.acsh.org/factsfears/newsID.1179/news_detail.asp. Despite being unable to defend their results, the Organic Center scientists continue to perpetuate the fiction that "organic food contained, on average, 25% higher concentrations of nutrients" on their website (Benbrook and others 2009a) and in correspondence to the American Journal of Clinical Nutrition (Benbrook and others 2009b). They claim that they made sure the matched pairs they included in their report consisted of identical cultivars (varieties) grown in the same soil type in the same geographical area, variables long known to have profound effects on total phenol content (Hornick 1992).

One variable Benbrook and his colleagues did not pay attention to is the effect of harvest year on changes in total phenol, individual flavonoid, and/or antioxidant capacity.

For example, organic Burbank tomatoes grown in 2003 had 84% more quercetin, 88% more ascorbic acid and 43% more total phenols than conventional Burbank tomatoes (Chassy and others 2006). However, the organic tomato crops grown in 2004 and 2005 had 5% and 14% LESS quercetin, respectively, than tomatoes grown conventionally in those years. Similarly, while tomatoes grown organically in 2003 had a higher (43%) total phenol concentration than conventional tomatoes, there was only a 6% increase for organic tomatoes in 2004. In 2005, the organic tomatoes had an 18% lower total phenol concentration than the tomatoes grown conventionally. Wide variations were also observed for ascorbic acid concentrations between organic and conventional tomatoes over those 3 y: +88% in 2003 but only +2% in 2004 and +7% in 2005.

Ninfali and others (2008) reported significantly higher levels for total phenols in *Leccino* organic olive oil in 2002, but the results were reversed in 2003. There was no significant difference in 2001. For the *Frantoi*o variety, 2001 was a very good year for organic olive oil but the situation was completely different in 2002. There was no statistical difference between organic and conventional oils in 2003. Significant changes in vitamin E concentrations with harvest year were also observed by these investigators.

As discussed earlier, organic peaches harvested in 2004 had higher total phenol concentration than conventional peaches, but opposite results were obtained in the 2005 harvest (Fauriel and others 2007). The 2004, but not the 2005, results were reported by the Soil Assn. and the Organic Center (Soil Assn. 2007; Benbrook and others 2008).

Other research groups that found growing season to have a profound effect on antioxidant activities were Howard and others (2003), Demberg and others (2005) Garcia and Barrett (2006), and Mogren and others (2007) in blueberries, oats, tomatoes, and onions, respectively.

Very few of the matched pair studies cited by the Organic Center (Benbrook and others 2008) were conducted for more than 1 y meaning that any of the conclusions coming from that study are not definitive. Despite that, the Organic Center had a number of complaints about the Dangour report.

Specific Organic Center Complaints

One complaint (Benbrook and others 2009a) was that an important quality, total antioxidant capacity, was not addressed by the British scientists. However, the Organic Center listed only 8 comparisons between organic and conventional crops in this category in their own report (Benbrook and others 2008). Three of these comparisons (Rembialkowska and others 2007) were not peer-reviewed and one was the questionable (Amodio and others 2007) kiwi study. The difference between organic and conventional pac choi was not statistically significant (Zhao and others 2007). One study indicated a small advantage for conventional tomatoes, but was not statistically significant (Lumpkin 2005).

A 2nd complaint was that the Dangour study found no differences in the phenolic content of the 25 matched pairs that the Organic Center (Benbrook and others 2008) had studied. Of these 25 matched pairs, only 5 of the organically grown pairs (1) had more than a 10% advantage over their conventionally grown matches, (2) were published in peer-reviewed journals, and (3) were statistically significant. And of the 5 remaining matched pairs, one was the questionable kiwi study (Amodio and others 2007); a 2nd study in this group found a statistically significant increase of phenolic content in organic pac choi, but the pac choi was infested with flea beatles and was inedible (Young and others 2005).

A 3rd complaint was that the Dangour group did not include the higher levels of the "key antioxidant," quercetin. According to Benbrook and others (2008), 11 of the 15 matched pairs in their study showed higher levels of quercetin in organic crops, but only 7 were statistically significant. In 5 of these statistically significant differences the organic farmer applied chitosan (poly-D-glucosamine, CAS 9012-76-04), a natural fungicide, to his crops (Ren and others 2001). Since chitosan stimulates the enzymes that catalyze quercetin production (Khan and others 2003), it is obvious that Ren's study should not have been included.

A 4th complaint was that Dangour and his group did not find evidence, as many others had, for lower nitrate concentrations in organic crops. The problem with nitrate, according to the Organic Center is that "most scientists" (was there an election?) regard nitrate "as a public health hazard because of the *potential* (italics mine) for cancer-causing chemicals to be formed in the human GI tract" (Benbrook and others 2009a).

But dietary nitrate is not only safe. . . . . .

There is no epidemiological evidence for a connection between nitrate in food and human cancer. The weight of current scientific evidence is that fruits and vegetables (even with nitrates) can protect against some cancers and the public is frequently admonished to eat at least "five a day." After completion of a thorough review on nitrate, the European Food Safety Authority (EFSA 2008), declared that "the estimated exposures to nitrate from vegetables are unlikely to result in appreciable health risks." Numerous studies provide strong evidence for a lack of a connection between nitrate intake and cancer (Forman and others 1985; Pobel and others 1995; Rogers and others 1995; Kono and Hirohata 1996). Another group (Duncan and others 1997) wrote "there is no epidemiological evidence for an increased risk of gastric and intestinal cancer in population groups with high dietary vegetable or nitrate intake."

. . . . . It's good for you!!

This group also found that nitrate fueled an important mammalian resistance mechanism against infectious diseases while other investigators (Larsen and others 2006) reported a statistically significant drop in systolic blood pressure after ingestion of sodium nitrate. Drinking 1 or 2 glasses of beet juice substantially lowered blood pressure in healthy volunteers (Webb and others 2008). Mice that were fed a high nitrate/nitrite diet were more likely to survive an induced heart attack (Bryan and others 2007). Nitrate has also been shown to protect against stomach ulcers and the gastric side effects of aspirin and other nonsteroidal anti-inflammatory drugs (Petersson 2008). A comprehensive

Table 1 — Numerical estimates for nutritional superiority of organic produce.

Author	Claim	Comment
Brandt and Molgaard (2001)	10% to 50% more nutrients	No data provided, just a "guess"
Benbrook (2005)	30% more nutrients	Based on only 5 studies: 2 did not meet standards for inclusion in 2008 Organic Center report; 1 not peer-reviewed; 1 comparison invalid
Leifert (2007)	"up to 40%" more nutrients	No experimental data to support claim in fruits and vegetables and it appears that there never will be
Benbrook and others (2008)	25% more nutrients, on average in organic fruits and vegetables than in conventional foods	Included key publications that were not peer reviewed; many results not statistically significant; included several invalid comparisons; ignored some unfavorable data; misclassified nitrate vegetables as unhealthy despite overwhelming evidence to the contrary
		Entire report not peer-reviewed
Rosen (2008b)	Correction of the errors and omissions in Benbrook and others (2008) indicates that there is essentially no nutritional difference between organic and conventional foods	Not peer-reviewed either
Dangour and others (2009)	No difference in nutrients and no difference in putative health effects	Methods and results peer-reviewed

review (Hord and others 2009) concludes that "the data on nitrate and nitrite contents of vegetables and fruit bolster the strength of existing evidence to recommend their consumption for health benefits" and that plant origin nitrates and nitrites "play essential physiologic roles supporting cardiovascular health and gastrointestinal immune function." Finally, an article published recently in *Medical Hypotheses* suggested that ingestion of high nitrate-containing fruits and vegetables such as pomegranates, lettuce, spinach, and beets might be useful in lowering obesity, diabetes, hypertension, and coronary artery disease (Ralt 2009).

Organic Food Proponents Are Unreliable Information Resources That Harm the Consumer

Organic food proponents do more than act as unreliable sources of information; they actually cause harm. For example, to obtain the supposed nutritional benefits of organic milk, you must drink milk that is high in saturated fat. Questions about the relationship between high intakes of ALA in organic milk and advanced prostate cancer (Leitzmann and others 2004) are not even addressed. The Organic Center's insistence that we should not eat conventional vegetables because they contain more nitrate than organic vegetables is inconsistent with emerging scientific evidence that nitrate may actually be beneficial in disease prevention.

Organic food proponents are so concerned with distinguishing their products from conventional food that they have campaigned against useful practices such as food irradiation and genetic modification. Despite the fears generated by organic food proponents and their allies, consumption of irradiated food is perfectly safe. And it would prevent much suffering. The Centers for Disease Control and Prevention estimates that if just 50% of the beef and chicken sold in the United States were irradiated, there would be almost 900000 fewer food poisoning cases, 8500 fewer hospitalizations, 6600 fewer catastrophic illnesses, and 352 fewer deaths every year (Tauxe 2000).

A tenet of organic food proponents is that the safety of genetically modified (GM) foods has not yet been established (even after billions of meals ingested without even one demonstrated illness). So it follows that any new genetically modified food has to be thoroughly tested before it can be allowed. One such food is Golden Rice, a new variety of rice genetically modified to produce beta-carotene, a precursor of vitamin A. Vitamin A deficiency is the leading cause of blindness among children in underdeveloped countries. Every year, about 500000 children become blind as a result of this deficiency, and 70% die within a year of losing their sight. Anti-GM activists have succeeded in preventing the commercialization of Golden Rice for about 10 y, arguing that Golden Rice should not be approved without clinical trials in humans. Now that Tufts Univ. is about to conduct such trials, an open letter has been sent to Tufts with a demand that "these unethical and potentially dangerous trials MUST be stopped" (GM Free Cymru 2009). One of the signatories to this letter is Dr. Leifert, who worries about the nonexistent risk from GM food but sees no problem with drinking milk containing ALA, an omega-3 fatty acid linked to increased advanced prostate cancer in men.

Incidentally, GM tomatoes have been grown with up to a 78-fold increase in flavonols, mainly due to rutin, a glycoside of quercetin (Robinson and others 2001) and, in another development, Monsanto has successfully incorporated a gene into soybeans that makes the enzyme that produces stearidonic acid (CAS nr 202290-75-9), a precursor of the omega-3 fatty acid, EPA. Recently, Harris and others (2009) disclosed at a meeting of the American Heart Assn.'s Scientific Sessions that GM soybean oil increased EPA levels in red blood cells. So if flavonols and omega-3 fatty acids live up to their hype, consumers will be able to readily obtain them from tomatoes and soybean oil.

In addition, organic food proponents cause unnecessary guilt and fear in people who cannot afford to buy overpriced (and completely useless) organic food for their children. The Organic Center, for example, claimed that purchase of organic food "would lower the incidences ADD, ADHD and autism in our children" (Davis 2006).

Some food activists have demanded that organic food should be provided to mothers and children in the government-funded WIC Program because it is "more nutritious." WIC stands for "Women, Infants and Children" and its mission is to "support low-income women who are at nutritional risk by providing food to supplement their diets." Government funding is a zero-sum game and if money is provided for more expensive (and unneeded) organic food there will be less food for those in need.

Although federally funded, WIC is administered separately by each state. Washington State has been criticized for not providing organic food to program participants. Their replies (Washington State 2009) provide a partial list of organizations whose members do not believe that organic food is more nutritious than conventional food:

1. The American Academy of Pediatrics and the American Medical Assn. have not supported the need for organic food.
2. The Mayo Clinic and the American Dietetic Assn. state that there is no benefit from organic food.
3. The U.S. Dept. of Agriculture states that there is no conclusion about the need for or benefit from organic food.
4. After a thorough study of WIC foods, the National Academy of Sciences, Inst. of Medicine made no reference to the need for organic food.

Conclusions

Table 1 gives a concise summary of the claims for the nutritional superiority of organic produce. Organic food proponents such as the Soil Assn. and the Organic Center are organizations with missions to promote and sell organic food. But in their zeal to fulfill these missions they many times stretch the truth. Much of the proof advanced by both the Soil Assn. and the Organic Center are based on research articles that have not been reviewed by independent scientists and data that are not statistically significant. Nonexistent or incomplete data are nevertheless "published" in the media. In some cases, organic food proponents omit data that do not support their views, the most egregious example being the trashing of conventional vegetables because some contain higher levels of nitrate than organic vegetables. Any members of the media who rely on organic food proponents for information without checking the facts are complicit in defrauding their readers. And any consumers who buy organic food because they believe that it contains more healthful nutrients than conventional food are wasting their money.

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