Claims of Organic Food's Nutritional Superiority:

A Critical Review

By Dr. Joseph D. Rosen

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Introduction

The Organic Center was founded in 2002 to "*prove* the benefits of organic," according to Walter Robb, Co-president and Chief Operating Officer of Whole Foods Market and a Member of the Board of the Organic Center (1). From time to time, the Organic Center publishes State of the Science Reviews. These reviews provide some useful information, but, as you might expect from an organization supported by the Organic Trade Association, large food companies and their CEO's (2), the information is usually spun in favor of organic food.

One such review, "New Evidence Confirms the Nutrient Superiority of Plant-Based Organic Foods," authored by Charles Benbrook and his colleagues (3), was published online in March 2008. In this critique, that review will be referred to as either Benbrook et al. or the "Organic Center Report."

Background

Free radicals are reactive chemical species produced during normal human metabolism. It is widely believed that they can initiate cancer by reacting with and damaging DNA. Free radicals can also contribute to coronary heart disease by oxidizing "bad cholesterol" to form arterial plaque. Antioxidants are capable of destroying free radicals, and that's why antioxidants are of so much interest. Health experts advise us to eat five to nine servings of fruits and vegetables every day because these foods are rich in vitamin C, vitamin E, beta-carotene, lycopene and chemicals known as polyphenols. All of these chemicals are powerful antioxidants. Two other powerful antioxidants, butylated hydroxytoluene and butylated hydroxyanisole, cannot be used in organic food because they are synthetic chemicals.

Some polyphenols are produced by plants in response to attacks by insects, fungi and weeds (among other stresses), and it is believed by some scientists that organic crops produce more of these chemicals than conventional crops because the latter are already protected against some of these stresses by synthetic pesticides. Flavonoids are a sub-class of polyphenols and a great number of these are found in food. Two flavonoids highlighted in the Organic Center Report are quercetin and kaempferol. There are a large number of polyphenols in food and it is very difficult to measure all of them individually. Therefore total polyphenols (or total phenolics, as they are sometimes called) are measured instead of, or in addition to, individual polyphenols.

A second theory is that slower release of nitrogen, as occurs when manure is substituted for synthetic fertilizer, results in higher polyphenol concentrations in food crops.

Report Methodology

An explanation of the methodology used by Benbrook et al. has been published (3). Briefly, they surveyed the scientific literature for publications comparing the nutrient value of organic and conventional food crops. Inclusion in these studies depended on several criteria set up by Benbrook and his colleagues. First, studies classified as acceptable or of high quality would include "a recognized experimental design with an appropriate statistical methodology for testing differences in nutrient levels." Unfortunately, Benbrook et al. sometimes ignored this goal for comparing nutrients.

Determination of statistical significance is of major importance in scientific studies where investigators wish to find out if the observed difference between, say, an experimental drug and a placebo occurred because there was a real difference or the difference occurred simply by chance. In order to test for statistical significance, three pieces of data must first be determined for each system: the number of replicated analyses, the mean of all the data in each system and the standard deviation of the mean. Peer-reviewed scientific journals will usually not permit publication of an article without this information.

(Statistical significance is certainly important, but sometimes statistically significant results are not meaningful. While it may be true that milk from cows raised on grass contained 46% more vitamin E and 50% more beta-carotene than grain-fed cows (4), it is also true that neither of these nutrients is found to any great extent in milk. An increase of 46% of vitamin E is the same as approximately 876 micrograms per quart of milk or less than 6% of the RDA for this vitamin. Increasing beta-carotene content of milk by 50% gets you approximately an extra 112 micrograms per quart, a lot less than the approximately 17,000 micrograms found in one medium size baked sweet potato.

In order to make comparisons between organically- and conventionally-grown crops several variables known to be responsible for nutrient differences have to be controlled. One such variable is the cultivar (or variety or genotype) of the crops being compared. For example, a kilogram of Empire apples contained 782 milligrams total phenolics, while Golden Delicious apples grown in the same orchard contained more than twice as much (5). Similarly, the Beltsville Elite variety of plums contained almost three times as much total phenolics as Stanley plums (6). The type of soil on which the crops are grown and the geographical location of the plants are also extremely important variables.

Benbrook and his colleagues were careful to include only those comparisons that controlled for these variables. Additional criteria such as from where the food was obtained (commercial farm, experimental farm, or food store), whether or not organic standards were followed for the organically grown crops, and the number of years the farm was managed organically were also considered important. Every paired comparison was rated for each of these criteria as either "of high quality," "acceptable" or "invalid." Points based on these criteria were assigned with 30 being the highest score obtainable. Paired comparisons with total scores above 12 were classified as Valid Matched Pairs. Comparisons that scored below 12 were deemed invalid and were not further considered.

Under this system, all the comparisons made in a publication authored by Asami et al. (7) were deemed invalid pretty much for some of the reasons that Alan Felsot and I noted several years ago (8). Asami et al. has been the most accessed paper of the Journal of Agricultural Chemistry for the past 3 years and has been cited repeatedly in newspapers and magazines as an example of the nutritional superiority of organic food.

One important variable not taken into account is changes in nutrient content between growing seasons. An excellent example of how this variable has an enormous affect on antioxidant content is shown in Chassy et al. (9). I have summarized those results in Table I. As can be seen, 2003 was a very good year for organic Burbank tomatoes, but the antioxidant content of organic and conventional Burbank tomatoes was about the same in 2004. Conventional Burbanks were nutritionally superior in 2005. A shopper who believed that organic food was more nutritious than conventional food would have made a wise choice (if cost was of no consideration) by purchasing the organic Burbank tomatoes in 2003. However, purchasing the organic tomatoes in 2004 and 2005 would have been a complete waste of money.

Table I. Variation of Antioxidant Content in Burbank Tomatoes Grown In Different Years[a]

Antioxidants	Year Grown	Conventional b	Organic b	Ratio (O/C) c	SS ?d
Quercetin	2003	3.43	6.30	1.84	YES
Quercetin	2004	1.18	1.12	0.95	YES
Quercetin	2005	3.32	2.84	0.86	NO
Kaempferol	2003	0.94	1.10	1.17	NO
Kaempferol	2004	1.51	1.78	1.18	YES
Kaempferol	2005	1.61	1.87	1.16	YES
Ascorbic Acid	2003	13.7	25.7	1.88	YES
Ascorbic Acid	2004	16.0	16.3	1.02	NO
Ascorbic Acid	2005	22.7	24.2	1.07	NO
Total Phenolics	2003	30.7	44.0	1.43	YES
Total Phenolics	2004	34.8	36.7	1.05	YES
Total Phenolics	2005	40.6	33.1	0.82	YES

a. Adapted from Chassy et al. (9).
b. Concentration of nutrient in milligrams per 100 grams of tomato.
c. O= Organically grown; C= Conventionally grown. Values below 1.00 indicate a greater antioxidant concentration in the conventionally grown tomatoes.
d. SS ?= Statistically significant as designated by Chassy et al.

Other research groups who found growing season to be a major variable were Dimberg et al. (10), Ninfali et al. (11), and Howard et al. (12). Two of these groups (11 and 12) also reported that vitamin E and total antioxidant capacity depended, in large part, on what year the crops had been harvested. Significant differences in antioxidant content were even found between identical crops harvested in different months of the same year (13, 14).Most of the valid matched pairs that were considered by Benbrook et al. were from data obtained during only one growing season, meaning that in spite of the care taken by these authors to make comparisons based only on organic vs. conventional agricultural practice, they were unable to do so because of large year to year variations in antioxidant content (see Table I).

Results and Critical Evaluations

Note: The headings used are the same as in Benbrook et al. (3).

Overview of Differences

Benbrook et al. (3) identified 232 (they claim 236, but they added incorrectly) valid matched pairs in comparisons they considered valid and that also satisfied their analytical methodology requirements. In the antioxidant category, there were 21 valid comparisons for total phenolics (referred to above as polyphenols), 8 for total antioxidant capacity, 15 for quercetin and 11 for kaempferol. (Note: Quercetin and kaempferol belong to a class of polyphenols called flavonoids.) They found 46 valid comparisons for vitamin C/(ascorbic acid), 8 for _-carotene and 13 for vitamin E. The minerals, phosphorous and potassium, accounted for 32 and 33 studies, respectively. Finally, there were 27 protein comparisons and 18 comparisons for nitrate. In most comparisons, organically-grown food appeared to be nutritionally superior to conventionally-grown food as shown here in Table II as adapted from Tables 5.1 and 5.2 in Benbrook et al. (3).

All of the results in the Organic Center Report are conveniently listed in an addendum (15) and are tabulated by nutrient, valid matched pair by study, year that the study was performed, nutrient concentrations of the organic and conventional components of each matched pair (in milligrams nutrient per kilogram fruit or vegetable) and the ratio of organic to conventional nutrient concentration. I have included those results in the last column of Table II.

A Detailed Examination of the Results in Table II

Quercetin. Of the fifteen matched pairs for this nutrient, one matched pair (9) showed an average 30% increase for quercetin in organic Burbank tomatoes for the years 2003-2005. Another matched pair showed 3% more quercetin in organic Wonder Bell peppers (9) while the Excaliber Bell pepper variety had 3% less quercetin in the organically grown vegetable (9). Organic black currants had 5% more quercetin than conventional black currants (16) and there was no difference between organic and conventional pac choi (17). So, for these five comparisons only the organic Burbank tomatoes had significantly more quercetin than conventional tomatoes, mainly because of the huge difference observed in only one of three growing seasons (Table I)

Four paired comparisons were declared not statistically significant (Ropreco tomatoes for 2003-2005 (9), collards, Kalura leaf lettuce and Red Sails leaf lettuce (17) by the scientists who published the results.

Huge increases for quercetrin (a metabolic precursor of quercetin) in five organically grown vegetables was reported (18). These comparisons are inappropriate, however, because the organic vegetables were grown in soil treated with chitosan and were also sprayed with this chemical whenever there were signs of insect infestation. Chitosan is a "natural" insect repellent that is extracted from insect exoskeletons and is permitted for use on both organic farms and conventional farms. When this chemical is applied to a plant, the plant "thinks" it is being attacked by insects so it produces large quantities of flavonoids to resist them. Induction of the enzymes necessary for the synthesis of flavonoids by chitosan is well known (19, 20).

So we are left with only one valid matched pair [Mitchell et al. (21)]. These investigators reported a 79% increase in quercetin content in organic tomatoes grown over a 10-year period. According to Professor Mitchell, however, the monoculture practices followed by the group that grew these tomatoes

Table II. Summary of Nutrient Content Differences in Conventional and Organic Food for 232 Valid Matched Pairs

Nutrient (Number of Matched Pairs)	Number (%) Organic Higher [a]	Number (%) Conventional Higher [a]	Number (%) Same [a]	Ratio Organicto Conventional [b]
Quercetin (15)	13 (87)	1 (7)	1(7)	2.38
Kaempferol (11)	6 (55)	5 (45)	0	1.05
Total Phenolics (21)	15 (71)	5 (24)	1 (5)	1.11
Antioxidant Capacity (8)	7 (88)	1 (13)	0	1.24
Vitamin C/Ascorbic Acidc (46)	29 (63)	17 (37)	0	1.10
Beta-carotene (8)	4 (50)	4(50)	0	0.92
Vitamin E (13)	8 (62)	5 (38)	0	1.15
Phosphorous (32)	20 (63)	10 (31)	2 (6)	1.07
Potassium (33)	14 (42)	19 (58)	0	1.00
Protein (27)	5 (15)	23 (85)	0	0.90
Nitrate (18)d	3 (17)	15 (83)	0	0.56

a. From data in Tables 5.2 and 5.3 in Reference 3
b. From tabulated data in Reference 15
c. Vitamin C consists of ascorbic acid and dehydroascorbic acid, but mostly the former
d. Benbrook et al. (3) consider higher nitrate content "undesirable"

are rarely, if ever, followed by commercial organic farmers, making it unlikely that these tomatoes will show up at your local Whole Foods Market anytime soon. It is also questionable if these tomatoes are even edible because quercetin and other polyphenols are known to impart a bitter taste at high concentrations (22). In any event, data obtained from crops that can not be purchased commercially, although scientifically interesting, do not belong in an article whose main purpose is to convince consumers to purchase organic food.

Kaempferol. Of the 11 valid matched pairs identified by Benbrook et al., only three differences were statistically significant: seventeen per cent more kaempferol in organic Burbank tomatoes, 19% more kaempferol in Ropreco tomatoes averaged over a 3-year period (9) and 97% more in the Mitchell study (21). The last study, as mentioned above, does not represent commercial organic farming practice. Another matched pair indicated a 1300% increase in kaempferol content in conventional cabbage (23) but this is an error as Benbrook et al. mistakenly compared levels of a kaempferol precursor, not kaempferol itself.

Total Phenolics. Measurement of total phenolics provides more information about the antioxidant potential of a food than measurement of individual flavonoids. Benbrook et al. (3) identified 21 valid matched pairs in this category.

Only 4 matched pairs demonstrated legitimate differences. Conventional Honeoye strawberries contained 14% more total phenolics than organically grown Honeoye strawberries but the reverse was true when organic and convention Cavendish strawberries were compared (23). Carbonaro et al. (24) found 36% more total phenolics in organic peaches while Sousa et al. (25) reported a 25% increase in organic cabbage.

No statistically significant and/or meaningful differences of more than 10% were observed in 11 valid matched pair comparisons: black currants (16), two varieties of leaf lettuce (17), collards (17), two tomato varieties (Burbank and Ropreco) (9), two Bell pepper varieties (9), pears (24), head lettuce (13) and tomatoes grown in Taiwan (29).
Six matched pairs should not have been used:

Three of these comparisons are based on a publication (26) that was not peer-reviewed and whose authors did not provide any information (standard deviation, number of replicates analyzed) that could be used to determine if the comparisons between the organic and conventional matched pairs were statistically significant. I am disappointed that Benbrook and his colleagues used the data in this "publication" for three of their categories (total phenolics, ascorbic acid/vitamin C, and antioxidant capacity).

Another paired comparison is based on an article authored by Fauriel and co-workers (27). This article was not peer-reviewed either and also provided no data that allowed others to determine if the results were statistically significant. Organic peaches grown in 2004 had 46% more total phenolics than conventional peaches. But the organic growing conditions caused a decrease in both yield and size of the peaches by more than 50%. When the organic farmers adjusted their growing conditions the following year to correct these problems, a spectacular reversal was observed -- the conventional peaches now contained 30% more total phenolics than the organic peaches. This led Fauriel and his colleagues to conclude that there were no statistically significant differences in total phenolics content between organic and conventional peaches over the two-year period, a conclusion ignored by Benbrook et al.

Amodio et al. (28) reported 17% more total phenolics in organically grown kiwis as well as a 14% vitamin C increase. The assay they used for measuring the phenolics also measures vitamin C. Unless vitamin C content is subtracted, total phenolics values are too high (7,9). There is nothing in the experimental section of their publication to indicate that this correction was made. In addition, Amodio et al. reported that the organic kiwis had 35% thicker peels than the conventional kiwis. Kiwi peel is inedible but that's where higher concentrations of phenolics are usually found. A more meaningful comparison would have resulted if Amodio and her co-workers tested only the edible portions of the kiwis.

Young et al. (17) reported 32% more phenolics in organic pac choi than in conventional pac choi, attributing the higher phenolics content to a flea beetle infestation. A photograph included by Young and her colleagues in their publication showed that the organic pac choi did not look too appetizing after the flea beetles feasted on it.

Antioxidant Capacity. Only 8 comparisons were found, 3 of them for the pasteurized apple purees (26) and one for the kiwis (28), both of which were discussed above. There were also 2 omissions in Benbrook's summary:

a. The late spring, 2004 comparison of organically- and conventionally-grown pac choi (13% higher antioxidant capacity in organic) was included; however, the late summer, 2004 harvest which "result ed in similar levels of antioxidant capacity" between organic and conventional pac choi (14) was omitted.

b. There were no statistically significant differences for antioxidant capacity between conventional and organic olive oil averaged over a three year period for both the Leccino and Frantoio varieties (11).

Vitamin E. Thirteen paired comparisons are listed, but one of them is for the milk of grass fed cows and another for meat from grass fed steers. Neither food is a significant source of vitamin E, no matter how much grass the animals eat. A third comparison lists values of 6.50 and 5.70 milligrams/kilogram for organic and conventional peaches, respectively. However, these values are the reverse of what was actually reported (24). None of the data for vitamin E in sweet corn is statistically significant (39).

Beta-Carotene, Potassium, Phosphorous. Only 6 valid matched pairs were found for beta-carotene; the organic/conventional ratio was listed as 0.92. The organic/conventional ratio for potassium averaged 1.00 for thirty-three matched pairs and the organic/conventional ratio for phosphorous averaged 1.07 for thirty-two matched pairs. In essence, there were no differences found between organic and conventional foods for these nutrients.

Protein. Analysis of twenty-seven valid matched pairs for protein favored conventional food 23-4, but the differences were small and for the most part, not statistically significant. In addition, Benbrook et al. point out that protein deficiency is not a problem in the American diet.

Vitamin C/Ascorbic Acid. Analysis of 46 valid matched pairs for ascorbic acid or vitamin C content favored organic produce by a score of 29-17. In general, organic produce averaged only 10% more vitamin C than conventional produce. If you think you're not getting enough vitamin C from conventional food, take a 10-cent multivitamin.

Nitrate. Some vegetables (spinach, lettuce, beets, radishes, celery, turnips, rhubarb and melons) are able to store nitrate better than other vegetables especially when grown in high nitrate-containing soils Synthetic fertilizers deliver more nitrate and other plant nutrients than the natural fertilizers used by organic farmers. This is reflected in the Organic Center Report where 15 of the 18 matched pairs contained significantly higher levels of nitrate. Benbrook et al. consider higher nitrate content "undesirable" but do not explain why. Perhaps it is because nitrate is converted by salivary enzymes to nitrite, which in turn is converted in the stomach to nitrous acid, a precursor of carcinogenic chemicals known as nitrosamines. But there is no epidemiological evidence for a connection between nitrate in food and human cancer. Actually, the reverse is true. People who eat lots of fruit and vegetables have lower cancer rates than those who do not (30, 31). The European Food Safety Authority assessed both the risks and benefits from nitrates in vegetables and concluded "the beneficial effects of eating vegetables and fruit outweigh potential risk to human health from exposure to nitrate through vegetables" (32).

Evidence that dietary nitrate may actually be good for us has been accumulating. A study published in the New England Journal of Medicine reported a statistically significant drop in systolic blood pressure after ingestion of sodium nitrate (33). In another study, drinking a glass or two of beet juice (a high nitrate food) substantially lowered blood pressure (34). Scientists writing in the Proceedings of the National Academy of Sciences reported that mice fed a high nitrate/nitrite diet were more likely to survive an induced heart attack. This article and a more reader-friendly discussion are available on-line (35). Other studies show that nitrate protects against stomach ulcers and side effects of aspirin and other non-steroidal drugs (36) as well as preventing infectious diseases in the gastrointestinal tract (37).

Magnitude of Differences

Benbrook et al. claim that the magnitude of the differences in nutrient levels between organic and conventional food is much greater in matched pairs where the organic food contained higher nutrient levels than in those matched pairs where the conventional food was found to have more nutrients (see Tables 5.3 and 5.4 in Reference 3). In order to examine this claim, I have constructed my own summary (Table III), which includes the original publications on which these claims are made. To save space, I have listed only the antioxidants and the vitamins, and consolidated Benbrook's 21-30%, 31-50%, and "over 50%" columns into one " 21% and over" column.

As summarized in Table III, Benbrook et al. identified a total of 38 valid matched pairs for antioxidants and vitamins where the organic part of the matched pair contained 21% or more nutrients than the conventional part of the pair. When a more critical examination of the actual data is applied, it turns out that there are only 12 such matched pairs, 9 of which can be eliminated by that 10-cent multivitamin

Table III. Number of Matched Pairs Where the Organically Grown Food Contained Twenty-one Percent or More Nutrient Than the Conventional Food Before and After Critiques.

Nutrient	Before Critiquesa	After Critiques	Reason for Changes
Total Phenolics	5	2	Footnote b
Antioxidant Capacity	4	0	Footnote c
Quercetin	11	1	Footnote d
Kaempferol	2	0	Footnote e
Vitamin C/Ascorbate	12	9	Footnote f
Beta-carotene	2	0	Footnote g
Vitamin E	2	0	Footnote h
Totals	38	12	

a. Adapted from Table 5.3 in Benbrook et al. (3).

b. No data to support statistical significance of differences for two apple purees (26); same problem for peach data (27)

c. No data to support statistical significance for three apple purees (26); kiwi determination included inedible skin (28)

d. Five comparisons involved use of the flavonoid elicitor, chitosan, in organic vegetables (18); three comparisons were not statistically significant according to authors (17); comparison for Ropreco tomato was not statistically significant according to authors (9); one study not meaningful to consumers (21)

e. One comparison was not statistically significant according to authors (9); another comparison was not meaningful to consumers (21)

f. Two comparisons involved grapes grown about 18 miles from each other and which were then processed into grape juice under different conditions (38) A third matched pair (25) used analytical methodology incompatible with the guidelines set up by Benbrook et al. (page 30 of Reference 3).

g. One comparison is between organic and conventional milk and is labeled "not plant based food" (15); a second comparison is identified as a statistical outlier (15). So why did these two results still wind up in Table 5.3?

h. One comparison reports a 140% increase in organic sweet corn grown in 1992 over conventional sweet corn, but this data is not statistically significant, according to the authors themselves (39). The second "valid matched pair" (46% more vitamin E in organic milk) does not belong in this review and is not meaningful because milk is not a good source of vitamin E.

Estimating Nutritional Premiums

In this section, Benbrook et al. tabulate the average organic to conventional nutrient ratios in Reference 7 and average them in Table 5.6 of Reference 3. Averaging the averages from the 11 nutrients gives an average organic to conventional ratio of 1.25, from which they conclude "The average serving of organic plant-based food contains about 25% more of the nutrients encompassed in this study than a comparable-sized serving of the same food produced by conventional farming methods." This is a completely unscientific way to make a comparison between different growing systems. For example, they assign equal weight to the 8 "antioxidant capacity" valid matched pairs and the 27 "protein" valid matched pairs. In addition, they assign equal weight to "quercetin" and "total phenolics" even though the latter is so much more important for estimating antioxidant differences between the two growing systems. In spite of my problem with the way they arrived at their conclusion, I will use the same system to calculate my own organic/conventional average ratio (Table IV).

The ground rules for this are simple: A ratio of 1.00 will be assigned to:

a. Any organic/conventional matched pair ratio between 0.91and 1.10.

b. Matched pairs from publications with an inadequate description of how statistical significance was determined.

c. Matched pairs considered not statistically significant by a study's authors.

d. Matched pairs where either component is inedible.

e. Matched pairs where flavonoid elicitors (such as chitosan) are used for only one component of the pair.

Furthermore, results from organic or conventional farms that do not follow the practices of commercial farms will not be included.

Table IV highlights two major differences between the Organic Center's calculations and mine. The concentration of quercetin in organic food drops from 140% "better" to 2% "better," once you examine the data and the experimental procedures in the publications on which the higher number is based. The second major difference is caused not by the nitrate data, but by the designation of nitrate as an "undesirable nutrient" in the Organic Center Report. Because of this improper designation, the actual value of the organic to conventional ratio, 0.56, was inverted to 1.80 without any explanation that there really is no evidence to label nitrate undesirable. Several errors were made in determining the organic/conventional ratio for vitamin E, such as a transposition error in recording data from Carbonaro et al. (24), the use of data which was not statistically significant in the sweet corn comparisons (39) and the inclusion of milk data in a review dealing with fruits and vegetables. In spite of the huge increase in vitamin E content in the organic milk (4), a person would have to drink about 17 quarts of organic milk every day in order to reach the recommended daily allowance (RDA) of 15 milligrams vitamin E.

Table IV. Differences in the Nutrient Content in Organic and Conventional Foods Across 11 Nutrients and 232 (Not 236) Matched Pairs:
A Comparison Between Results Published by The Organic Center and This Critique.

Nutrient	Average Ratio of Organic to Conventional Values Before Corrections [a]	Average Ratio of Organic to Conventional Values After Corrections
Antioxidants		
Total Phenolics	1.10	1.03
Antioxidant Capacity	1.24	1.06
Quercetin	2.40	1.03
Kaempferol	1.05[b]	1.02
Vitamins		
Vitamin C/Ascorbate	1.10	1.10[c]
Beta-carotene	0.92	0.95
Vitamin E	1.15	1.01
Minerals		
Phosphorous	1.07	1.07[c]
Potassium	1.00	1.00[c]
Other Nutrients		
Nitrate	1.80[d]	0.56
Protein	0.90	0.90[c]
Average ratio	1.25[b]	0.98

a. This column copied from Table 5.6 in Benbrook et al. (3)
b. The kaempferol value is really 1.15 and the average ratio really is 1.26
c. Changes would not result in any meaningful differences
d. This number was obtained by inverting the actual value, 0.56, to reflect Benbrook et al.'s decision to designate nitrate as undesirable

Conclusions (Theirs and Mine)

Their Conclusions

1. Based on the study's "rigorous methodology," organic plant-based foods are more nutritious in terms of their nutrient density.

2. The average serving of organic plant-based food has about 25% more nutrients than a conventional serving.

My Conclusions

The methodology in this study was anything but rigorous as results that were not statistically significant were used throughout, non-peer reviewed papers were included and much relevant data, such as the studies of Ninfali et al.(11) and Barrett et al, (40) were not included. Results favorable to conventional food were ignored in some cases [Rattler et al. (13), Zhao et al. (14), Fauriel et al. (27)]. Typographical errors, too numerous to list, were found throughout the report, especially in the addendum (15). Whoever calculated the organic/conventional ratios in the addendum should be sent back to Chemistry 101 to learn about significant figures.

Benbrook and his colleagues have no clue if organic food has 25% more nutrients than conventional food as they apparently did not consider how much weight to give to each category and so much of the data they used to get to this value was wrong to begin with. But in order to lend some credence to Conclusion 2, they point out that the 25% figure "is roughly the same margin in favor of organic food reported in the Organic Center's 2005 State of Science Review on antioxidants" (41). In that report, Benbrook used five literature studies to make his case. Two of these studies, Asami et al. (7) and Lombardi-Boccia et al. (42) were rejected as invalid for the 2008 report. The third study's (18) results were due to the use of chitosan and did not result from any difference between organic and conventional farming. The fourth study, which used results from different vineyards, was not peer reviewed (43). The authors of that study stressed that their results were prelimimary and further research would be needed to verify if the differences they found occurred on a regular basis. Almost eight years have passed since this work was first presented and I have seen nothing further on this topic in the scientific literature.

I do not know if my 0.98 ratio value is correct either, nor is it important. What I do know is that a consumer who buys organic food thinking that it is more nutritious is wasting a considerable amount of money. Even if organic advocates turn out to be correct in their assertions that organic food has more nutrient content than conventional food when tested against each other in valid matched pairs, how is the consumer going to use this information to make the right choice? Except for just a few fruits and vegetables, the consumer can not tell what variety of a crop is being offered for sale, thus making the selection of organic or conventional a crap shoot. Nor does the consumer know if this has been a good year nutrient wise for organic or a good year for conventional (see Table I) for that particular fruit or vegetable. What type of soil was that organic broccoli grown in? Was that soil better for nutrition than the soil in which the conventional broccoli in the next bin was grown? How about the geographic location of each organic and conventional farm? How about the amount of sunlight or water? How long ago did the organic choice leave the farm compared to the conventional choice?

References

Note: Many of the journal references below are costly to obtain. However, by entering the article's title into "this exact wording or phrase" on Google.com, the abstract of the article can be obtained (except Reference #8, which has no abstract).

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