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Organic Fruits and Vegetables: Potential Health Benefits and Risks

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INTRODUCTION

Organically grown food is food that has been produced without the use of synthetic pesticides, synthetic fertilizers or sewage sludge, bioengineering, or ionizing radiation (USDA, 2002a). Since 1990, the organic food industry has grown between 20 and 25 percent annually, reaching retail sales of approximately \$7.8 billion in the US in 2000 (USDA, 2002b). Beginning in 2000, more organic food was purchased in conventional supermarkets than in any other venue. Organic products are now available in nearly 20,000 natural food stores and are sold in 73% of all conventional grocery stores (Dimitri and Greene, 2002). The rapid growth of the organic food industry necessitated some form of uniform oversight that, beginning in October 2002, the USDA placed national standards upon anything sold under the label of “organic” (2002a).

Fresh produce is the top-selling organic food category, making up for 40% of all organic food sales in 2001 (Sloan, 2002). Despite the higher prices of organic food (Sok and Glaser, 2001), 3% of survey respondents regularly bought organic products, and among the top reasons for doing so were nutrition and health (Sloan, 2002). While these are commonly held reasons among consumers, the USDA states on its website that it “makes no claims that organically produced food is safer or more nutritious than conventionally produced food” (2002a).

Are organic fruits and vegetables really better than conventional produce for the health of the consumer? This review will explore the scientific evidence behind the issues of nutritional value, pesticide contamination, and microbiological safety.

NUTRITIONAL VALUE

Several reviews have been published that have attempted to definitively compare the nutritional quality between organic and conventional crops (Bourn and Prescott, 2002, Worthington, 1998, and Woese *et al*, 1997). However, each one has reached a similar conclusion that definitive conclusions cannot be drawn due to the lack in quantity and quality of comparable data. Nevertheless, some generalized trends have been observed.

Bourne and Prescott reviewed 38 studies, published over the last 30 years, and concluded that, with the possible exception of lower nitrate content in organic crops, there is no strong evidence that organic and conventional crops differ in concentrations of various nutrients.

Worthington (1998) reviewed 34 studies, published over the previous 50 years, and observed that organic crops had lower nitrate levels in 61% of the studies and higher vitamin C levels in 58% of the studies. Woese *et al* reviewed over 120 studies, the earliest dating back to 1924, and also observed that there was strong evidence for lower concentrations of nitrate in organic vegetables and higher levels of vitamin C among organic potatoes and leafy vegetables.

In 2001, Worthington standardized and statistically analyzed data obtained from 41 studies that compared organic with conventional crops (2001). The author found statistical significance in higher levels of vitamin C, iron, magnesium, and phosphorus, and lower levels of nitrates among organic crops. Another trend that was observed was a lower amount of protein in organic crops, but of higher quality. These findings were attributed to that fact that organic fertilizers, in contrast to synthetic fertilizers, contain less nitrates and deliver nutrients in a more consistent manner.

In general, the data seems to show the trend that organic crops have higher levels of vitamin C and lower levels of nitrates when compared to conventional crops. Further research of better quality than that which is currently available is needed to confirm these observed trends and to draw any other conclusions. Cross-comparison of studies on the nutritional value of organic and conventional crops is inherently difficult due to the variation in study conditions,

which can potentially affect crop nutrient composition. Factors include plant genetics, climate, fertilization and management practices, harvest time, and storage and handling conditions. In order to draw definitive conclusions, studies that compare crops grown organically or conventionally need to be conducted on identical strains of crops grown and stored under otherwise similar conditions.

PESTICIDE CONTAMINATION

Organic fruits and vegetables are believed to be healthier by many because organic farming methods prohibit the use of most synthetic pesticides used in conventional farming methods. Given their method of production, it makes intuitive sense that organic produce should contain less pesticides than conventional produce. However, until the last few years there was little to no published data on whether this intuition was correct, and if it was, exactly how much organic produce differed quantitatively from conventional produce.

Baker *et al* (2002) published a key study where the authors analyzed pesticide residue data sets from three US testing programs: the USDA’s Pesticide Data Program (PDP); the California Department of Pesticide Regulation (DPR) Marketplace Surveillance Program; and the Consumers Union (CU), an independent testing organization.

The PDP data set, collected from 1994-1999, contained data from tests of 127 organic and 26,571 conventional samples, most (>80%) of which were obtained through retail venues throughout the US. The California DPR data set, collected from 1989-1999, contained data from tests of 1097 organic and 66,057 conventional samples obtained at all levels of the production chain. The CU data set, collected in 1997, contained data of 67 organic and 68 conventional store-bought samples of four kinds of produce--apples, peaches, green peppers, and tomatoes—known for having a higher than average likelihood of containing pesticide residues.

The findings from the data analysis can be found in the following tables. Table 1 shows that conventional samples are approximately three times more likely than organic samples to contain one or more pesticide residues. Table 2 shows that conventional samples are also more likely than organic samples to contain multiple pesticide residues.

Of the samples that tested positive for pesticide residues, organic samples were paired to conventional samples of the same crop type and pesticide concentrations were compared. In 68% of the pairings from the PDP data set, 60% of the pairings from the DPR data set, and 71% of the pairings from the CU data set, the organic sample had a lower pesticide concentration than its conventional counterpart.

In summary, Baker *et al* showed that organic samples, when compared to conventional samples, are less likely to contain detectable pesticide residues, are less likely to

Table 1—Percentages of Samples Testing Positive for One or More Pesticide Residues

Data Set	Organic Samples	Conventional Samples
PDP	23%	73%
DPR	6.5%	31%
CU	27%	79%

Table 2—Percentages of Samples Testing Positive for Multiple Pesticide Residues

Data Set	Organic Samples	Conventional Samples
PDP	7%	46%
DPR	1%	12%
CU	6%	44%

contain multiple pesticide residues, and have lower concentration of pesticide residues approximately two-thirds of the time.

It is important to note that organic produce is not completely free of synthetic pesticides. Possible reasons for this include mislabeling or violation of organic methods, but most likely the presence of pesticides is due to unavoidable environmental contamination from pesticides carried by wind, contaminated water supplies, or persistent pesticide residues in soil previously used to grow conventional crops. An example of the last is organochlorine (OC) insecticides (such as DDT) that were banned many years ago but are known to persist in soil and contaminate both organic and conventional crops. Forty percent of the pesticide residues detected in the organic samples from the PDP data set were OCs. Due to unavoidable contamination, the USDA national standards allow, in organic crops, 5% of the applicable US Environmental Protection Agency (EPA) pesticide tolerance level for conventional crops.

It is generally agreed upon that dietary pesticide residues are a significant health concern, yet the long-term health implications of pesticide residues in the diet remain to be determined. Pesticides are subject to multiple layers of federal and state regulation and must be registered with the EPA to ensure issues such as food safety. Large-scale studies on the long-term effects of dietary pesticide consumption need to be conducted before arriving at any definitive conclusions concerning the health benefits of fewer and lower levels of pesticides in organic produce.

MICROBIOLOGICAL SAFETY

According to the USDA organic standards instituted in 2002, organic crops can be fertilized with natural sources of nutrients such as animal manure, plant debris, fish emulsion, and kelp (2002). Because foodborne pathogens such as *Salmonella* and *Escherichia coli O157:H7* may reside in the gastrointestinal tracts of animals and thus make their way into the manure, it has been suggested that organic crops may contain higher levels of pathogenic bacteria than conventional crops. Safeguards against the potential microbiological danger of manure have included composting the manure at 55-77 °C or allowing the manure to age at least 90 days before harvest (Mukherjee, 2004). However, the efficacy of safeguard measures such as these remained uncertain until two studies were published in 2001.

In one study, McMahon and Wilson (2001) tested 86 samples of organic vegetables, obtained from markets in Ireland, and detected no presence of *Salmonella*, *Campylobacter*, *Escherichia coli*, *E. coli O157:H7*, or *Listeria* in any of the samples. In the other study, Sagoo *et al* (2001) tested 3,200 samples of organic vegetables obtained from markets throughout the UK and found that *E. coli* was present in a low prevalence of 1.5% of the samples, but *Listeria monocytogenes*, *Salmonella*, *Campylobacter*, and *E. coli O157:H7* were all absent.

Mukherjee *et al* conducted an even more informative study, comparing the level of microbiological pathogens between organic and conventional crops. The authors collected 476 and 129 samples of fruits and vegetables directly from 32 organic and 8 conventional Minnesota farms, respectively. Of the 32 organic farms, 8 were officially certified while the remainder claimed to operate under organic protocols. The samples were tested for the presence of *E. coli* and the two leading foodborne pathogens, *E. coli O157:H7* and *Salmonella*. The authors found that the overall prevalence of *E. coli* in organic produce was 6-fold greater than that in conventional produce (9.7% vs. 1.6%), but the prevalence in organic produce was skewed by one uncertified organic farm that used untreated manure throughout the harvest process. When only taking into account the data from the certified organic farms, the prevalence of *E. coli* in certified

organic produce was 3-fold higher than that in conventional produce (4.3% vs. 1.6%). *E. coli* O157:H7 was not isolated in any organic and conventional produce samples, but *Salmonella* was found from one organic lettuce and one organic green pepper, interestingly obtained from one of the organic farms that tested negative for *E. coli*. None of the *E. coli* tested positive for possessing shiga toxin.

Based on the complete absence or extremely low prevalence of microbiological pathogens in organic produce from the studies described, the assertion that organic produce has greater microbiological contamination does not seem to be supported. However, the observation in the study by Mukherjee *et al* that the prevalence of *E. coli* was significantly higher in organic produce supports the idea that organic produce is more susceptible to fecal contamination. The authors observed that the produce from certified organic farms was 2.6 times less likely than uncertified farms to have *E.coli*. Assuming that certified organic farms adhere to the USDA requirements for treatment of manure before use, this significant difference may reflect the importance of certification as a potential means to ensure minimum fecal contamination of fruits and vegetables.

CONCLUSION

The health benefits and risks of organic fruits and vegetables are issues of significant importance due to the increasing popularity of organic food. The current literature shows that organic produce, in comparison to conventional produce, tends to contain higher levels of vitamin C and lower levels of nitrates, though more well controlled studies are necessary in order to reach any definitive conclusions. It has been definitively shown that organic produce contains fewer and lower levels of pesticides than conventional produce, though the long-term health consequences of ingestion of pesticides, and the clinical relevance of fewer and lower levels of pesticides in organic food, has yet to be determined. Organic farming methods can potentially lead to microbiological contamination, but the literature has shown that organic produce does not carry any higher risk of significant microbiological contamination than conventional produce. Taking into account the issues of nutrient content, pesticides, and microbiological safety, the current evidence seems to suggest that organic produce can potentially be more beneficial, but certainly not more harmful, than conventional produce for the health of the consumer. However, very few actual benefits have been demonstrated, and at present, the best recommended diet remains as one that is balanced and rich in fruits and vegetables, regardless of organic or conventional origin.

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