

Enhancing Food Nutritional Quality and Human Health Through Organic Farming Systems



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2nd International Symposium on Human Health Effects of Fruits and Vegetables



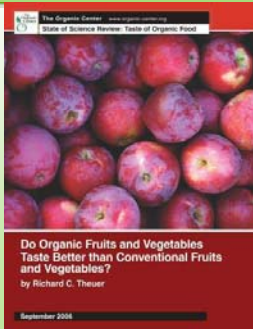
Taste and Fruit Quality – A Major, Ongoing Challenge



Results of The Organic Center's Taste "State of Science Review"

Organic apples most well studied – results consistently show higher organoleptic quality in organic apples

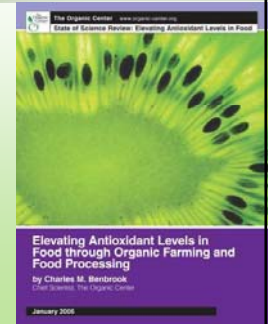
TOC-funded WSU strawberry fruit quality project found consistent – and positive – differences between organic and conventional berries



Antioxidant SSR

Describes their critical role in health promotion

Average antioxidant intakes are about one-third optimal levels – a major reason why USDA is recommending a 2-X plus increase in fruit and vegetable intakes



Phytochemicals in Strawberries



(units per g FW)	CON	ORG	METHOD
Polyphenols (mg gallic acid)	1.22	1.37	Folin-Ciocalteu
Flavonoids (Abs 325 nm)	14.0	15.6	HCl-methanol
Anthocyanins (μmol)	319	350	HCl-methanol Pelargonidyn-3-glucoside

Source: Unpublished findings of Washington State University Fruit Quality Project



Conclusions from WSU Apple and Strawberry Studies



- Organic yields are often lower and fruit size smaller, but fruit stores and tastes better
- Organic apples are as firm or firmer, and organic strawberries are sweeter
- Organic fruit has, on average, higher antioxidant activity and polyphenol content



“Still No Free Lunch” Critical Issue Report, September 2007

Discusses impact of rising yields on nutrient density


Focuses on critical role of high-nitrogen systems in increasing yields – but also the negative consequences of American ag’s near-exclusive focus on quantity produced, not quality



The Dilution Effect

- Yield-enhancing methods tend to decrease nutrient concentrations
- Term first used in Jarrell WM, Beverly RB, *Advances in Agronomy*, 1981; 34:197–224; brought back by Don Davis circa 2004






Nutrient Content SSR


Analysis of 85+ published studies comparing nutrients in conventional and organic food

Studies screened for experimental design, agronomics, soils, and analytical methods

Project nearly complete, some preliminary results follow



Nutrient Content Database






85+ published studies since 1980

About 140 crop/foods analyzed

Database will be kept up to date and used for several projects

* Latest addition – Perez-Lopez et al., 2007, *J. Food and Ag Chemistry*, October 3, 2007 (read on the plane), re organic sweet peppers have higher carotenoid and total antioxidant capacity




A Rapidly Expanding Database

	2007	2006	2005	2004	2003	2002	2001	2000	1999-1995	1994-1990	1989-1980	Pre-1980	Total
Number of Published Studies	5	7	15	8	4	1	5	5	14	11	8	0	83


May 2007-2004 = 35 42.2%

Pre-2000 = 33 39.8%

About 15-20 new studies per year likely, half in JFAC!!





Source: Unpublished findings, Organic Center Nutrient Content SSR



Nutrient Content Database Content




- General information (author, source, year)
- Food form tested (fresh, dried, frozen, oil)
- Experimental design
- Study carried out on a commercial farm, experiment station, or other location

Nutrient Content Database

Agronomic information –



- Cultivar
- Production methods
- Location
- Soil type and topography
- Nutrient levels and fertilization
- Pest control
- Cultural practices

Nutrient Content Database

For organic fields/crops –



- Organic standard followed (IFOAM, USDA/NOP, biodynamic, JAS)
- Years under organic production

Nutrient Content Database



Crop/food attributes –

- Yield
- Dry matter
- Organic acids
- Vitamins and minerals
- Carotenoids
- Phenolic compounds
- Antioxidant activity


Nutrient Content Database: Screening Criteria

- Current Organic Center study is focused on comparative field trials
- Experimental design and agronomic practices screen
- Analytical methods screen

Experimental Design and Agronomic Practices Screen

	High Quality	Acceptable	Invalid
Experimental Design	6	3	0
Soil Type	6	3	0
Cultivar/Genetics	6	3	0
Type of Study	4	2	0
Organic Standards	4	2	0
Years Under Organic	4	2	0
Maximum possible = 30		Acceptable >= 12	






Results of the EDAP Screen

138 crop/foods (as of October 1, 2007):

- 94 acceptable
- 44 invalid




Several of the “invalid” studies are high quality food purchase studies
 (E.g. Ishida and Chapman, “A comparison of carotenoid content and total antioxidant activity in catsup from several commercial sources in the United States,” *JFAC*, 2004)



Analytical Methods Screen

- Focus on individual methods by food/crop
- Published methods acceptable, unless reported data raises questions
 - Baseline resolution
 - Separation
- CV or RSD less than 16% and bias percentile lower than 12%
- Outlier values trigger more in depth assessment



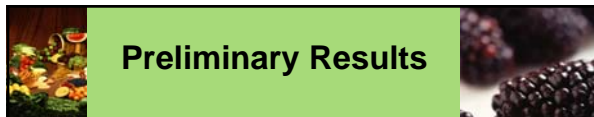
Preliminary Findings

Among vitamins –

- Organic production typically increases Vitamin C, but often reduces beta-carotene

Among minerals –



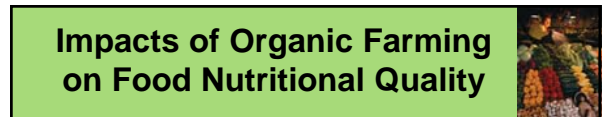
- Organic production typically increases some minerals and reduces nitrates (a good thing)

Preliminary Results

Organic production typically increases both total phenolics and antioxidant activity


Often, greater portion of phytochemicals in aglycone form, likely enhancing bioavailability

Impacts of Organic Farming on Food Nutritional Quality

For some key nutrients, organic production will typically, but not always, increase nutrient density –


- Better understanding needed of how to design and manage “nutrient-dense farming systems”
- Conventional, high-nitrogen production systems likely to continue to produce higher levels of protein and some vitamins




Implications for Human Health



Consumption of organic produce will increase average daily antioxidant intake by about as much as an additional serving of most fruits and vegetables





Implications for Human Health


Nutrient dense organic fruit and vegetables reduce the number of calories required for individuals to meet daily nutrient needs –

- 30-X or more antioxidants per serving compared to low nutrient dense foods
- Only 10% to 15% of total caloric intake needed to meet most nutrient needs


Source: Organic Center Antioxidant SSR




Implications for Human Health




Increased levels of some antioxidants in organic produce – e.g. resveratrol – likely to help trigger satiety



- More intense flavors in organic produce, especially when picked ripe, may also lessen tendency toward excessive caloric intake





Critical Areas of Inquiry




Impacts of organic farming on sugar levels and metabolism in plants **and** people

Do plants sometimes suffer from a diabetes-like syndrome?

Sugar Levels and Metabolism in Plants




Conventional systems dependent on high nitrogen fertilization rates produce –


- Faster growth, bigger fruit, larger average cell size – factors leading to the “dilution effect”
- Higher levels of protein and nitrates

But also –

- Less intense flavors and shorter shelf life
- Greater susceptibility to pathogens and insects






Sugar Levels and Metabolism in Plants




Impacts of high-N production systems on fresh produce –


- More sugar and moisture
- Greater percentage of nutrients in glycosylated form, plus, in many cases, more complex and stable forms of glycosylation


Sugar Levels and Metabolism in Plants: Possible Human Health Implications




More stable, complex forms of glycosylation, coupled with higher sugar levels in food, might lead to –




Reduced or delayed bioavailability as food moves through the GI tract, and/or insulin resistance and increased risk of diabetes

More AGEs in the food supply when fruits and vegetables are heat treated, or fried in oils (e.g., French fries)??




Causes and Characteristics of Human Diabetes and Plants with a Diabetes-Like Syndrome

Plants	Humans
Driven by excess sugars linked to nitrogen fertilization levels	Driven by excess sugar and abnormal sugar metabolism
Excess sugar triggers physiological changes that can increase vulnerability to pathogens and insects	Excess sugars trigger vascular changes that can lead to multiple complications, including increased risk of infectious disease





Causes and Characteristics of Human Diabetes and Plants with a Diabetes-Like Syndrome

Plants	Humans
Excess sugars alter nutrient levels and bioavailability (in plants), with complex impacts on regulatory proteins, growth, and defense mechanisms. Tendency to support/continue vegetative growth.	Excess sugars contribute to weight gain and may alter bioavailability and benefits of ingested vitamins and antioxidants
Increase in levels of ROS may lead to cell damage, increased vulnerability to pathogens, and weakened responses to biotic/abiotic stress.	Increase in ROS may trigger inflammation-based vascular damage, increasing vulnerability to multiple complications and weakening ability to respond to stress and infectious disease






Final Thoughts



Compared to conventional high-N systems, there is more potential to increase the nutrient content of produce through organic farming, over and above genetic advances, unless...


...conventional production systems move in the direction of organic, as many now are


Final Thoughts

The flavor, nutritional quality, and food safety benefits stemming from organic farming could be eroded if organic farmers strive to attain conventional yields –

- High N organic systems will likely dilute flavors and nutrients (but increase protein)
- Pushing organic systems to match conventional yields will jeopardize the soil quality and biodiversity-based benefits of organic farming




Final Thoughts



Today's focus on comparative levels of individual nutrients is likely missing the full impact of plant breeding and alternative production systems (what Joel Kimmons called "synergy" in his Thursday morning talk) –

- Key role of ratios and balances among nutrients in plants and people
- Glycosylation status and AGEs likely have major implications for plant and human health



Challenges for Farmers and the Food System

Grow and market more flavorful, nutrient dense fruits and vegetables – organic and conventional



Identify and refine production methods, genetics, and systems that can both enhance yields and nutrient density




Challenges for Farmers and the Food System



Better understand, and then manage, sugar levels and metabolism to promote plant and human health –

- Explore whether reducing the prevalence/severity of the diabetes-like syndrome in plants might help slow the increase in, and progression of, human diabetes

Thank you.