
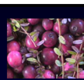


AAAS 2006 – St. Louis, MO

Understanding and Nourishing the Roots of Food Quality

Phytochemicals:
From Agricultural Practices to Human Health

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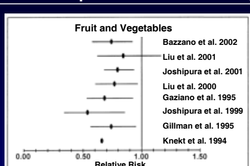
Are Organic Foods Better for Health?

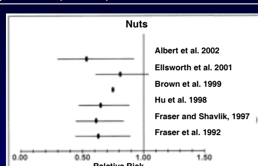
Hypothesis 1: Phenolics and related secondary plant metabolites are synthesized in response to enviornmental factors, including soil quality, irrigation, weed population, insect, and pathogen pressures.

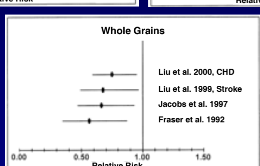
Hypothesis 2: Phenolics in foods grown by organic methods are significantly higher than in foods grown by conventional methods.

Hypothesis 3: Foods rich in phenolics promote dietary intakes associated with health promotion and disease prevention.

Prospective Cohort Studies of Cardiovascular Disease and Consumption of Fruits and Vegetables, Nuts, and Whole Grains







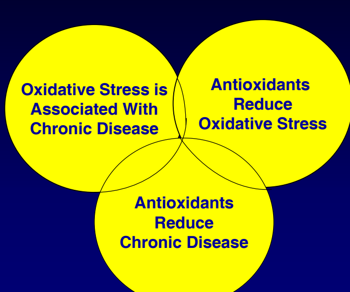
Hu et al. *Am J Clin Nutr 2003*

Quercetin and Risk of All-Cause Cancer

Quartile (mg/d) M	F	RR	95% CI
-	-	1.0	
1.5	1.8	0.93	0.79 - 1.09
2.5	2.9	0.97	0.82 - 1.14
3.9	4.7	0.77	0.65 - 0.92

P (trend) = 0.01
N = 9865 at risk, 1093 cases
Adjusted for sex, age, geographic area, occupation, smoking, BMI

Knekt et al. *Am J Clin Nutr* 2002



Chronic Degenerative Diseases Associated With Free Radical Damage

- Adult respiratory distress syndrome
- Age-related macular degeneration
- Alcoholism
- Aluminum neurotoxicity
- Alzheimer's disease
- Cancer
- Cardiovascular disease
- Cataracts
- Diabetes
- Down syndrome
- Familial amyotrophic lateral sclerosis
- Hemorrhagic shock
- Inflammation
- Ischemia
- Pancreatitis
- Parkinson's disease
- Porphyria
- Rheumatoid arthritis

Antioxidant Defense Network

Endogenous

ENZYMATIC
- catalase (Fe)
- glutathione peroxidase (Se)
- superoxide dismutases (Mn, Cu/Zn)

CELLULAR
- glutathione
- α-lipoic acid
- ubiquinone
- uric acid

PROTEIN
- ceruloplasmin
- ferritin
- transferrin

Exogenous

- ascorbic acid
- tocopherols/tocotrienols
- carotenoids
- simple phenols
- polyphenols

Bioactive Phenolics

Simple Phenols

acetophenones	phenolic acids
aldehydes	phenylpropanoids
benzoquinones	phylacetic acids

Polyphenolic Compounds

chromones	naftoquinones
coumarins	stilbenes
flavonoids	xanthones

Potential Links Between Polyphenol Mechanisms and Disease

Anticancer

Reduced inflammation

?↓

Reduction In allergies

? Antiviral
↓Cell proliferation
↓Angiogenesis
Antioxidant
Antithrombogenic
↓Cholesterol
↓Leukocyte immobilization
Chelation of iron
↓Complement activation
↓Myeloperoxidation
↓Cyclooxygenase
↓5-Lipoxygenase
Modulate NO

Reduction in cardiovascular disease

↑

Reduced ischemia-reperfusion injury

Nijveldt et al. *Am J Clin Nutr* 2001

Conventional vs. Organic Agriculture

Conventional Agriculture

Evolved in response to technological developments in mechanization/tillage, monoculture, synthetic fertilizer, irrigation, chemical pest and weed control, modified genetics, breeding

Organic Agriculture

USDA National Organic Standards (2000) prohibit genetic modification, irradiation, fertilization with sewage sludge, synthetic fertilizers and pesticides (>3y)

Effect of Organic Agriculture on Phytochemical Antioxidants

Food	Findings	Reference
Marionberry strawberry, corn	↑ TP, vC	Asami et al *JAFC* 2003
Peach, pear	↑ TP, ↑ PPO	Carbonaro et al *Food Chem* 2001
Peach, pear	↑ TP, ↑ PPO ↑ vC, ↓ vE (peach) ↑ vE (pear)	Carbonaro et al *JAFC* 2002
Vaccinium berries, strawberry	↔ quercetin, kampferol, *p*-coumaric acid	Hakkinen et al *Food Res Intl* 2000
Chinese cabbage, spinach, Welsh onion, green pepper	↑ TAC, ↑ flavonols ↑ flavones	Ren et al *Nippon SKKK* 2001

Comparisons between Conventional and Organic Agricultural Practices: Challenges

- Climate
- Crop rotations
- Duration under production
- Inputs
- Perennials - age
- Prevalence of pests
- Soil
- Water
- Geographic region*
- Variety*
- Planting/harvest times*

Variations in Organic and Conventional Agricultural Production

Chemical Inputs ↑

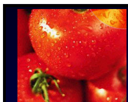
1. Conventional - industrial
2. Conventional - high input IPM
3. Convention – low input IPM
4. Organic – input substitution
5. Organic – management intensive
6. Organic – neglect/wild

? Least difference: 3 vs 4
? Most difference: 1 vs 6

Organic vs. Conventional Tomatoes: Total Phenols and Total Antioxidant Capacity

	Organic	Conventional
TP (mg GAE/g DW)	3.45 ± 0.6	3.1 ± 0.4
ORAC (μmol TE/g DW)	52.9 ± 18.0	41.7 ± 12.1

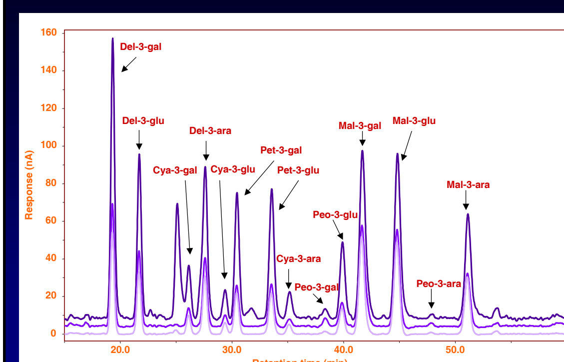
N = 10 pairs



Contrast Pairing: Organic vs. Conventional Tomatoes

	Organic	Conventional
TP (mg GAE/g DW)	3.3	3.0
ORAC (μM TE/g DW)	49.7	25.1

Blueberry Anthocyanins by HPLC-ECD



Traces: 400, 500, and 700 mV

Organic vs. Conventional Blueberries: Total Phenols, ORAC, Flavonoids, Anthocyanins

	Organic	Conventional
TP (mg GAE/g DW)	18.4 ± 2.5	17.6 ± 1.8
ORAC (μmol TE/g DW)	317 ± 40	311 ± 22
Total anthocyanins (mg/g DW)+	15.5 ± 3.1	14.5 ± 3.4*
Delphinidin-3-arabinoside (mg/g DW)+	2.0 ± 0.4	1.6 ± 0.3
Peonidin-3-glucoside (mg/g DW)+	1.0 ± 0.2	0.8 ± 0.3
Malvidin-3-glucoside (mg/g DW)+	0.8 ± 0.7	1.4 ± 0.8*

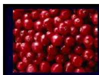
N = 8 pairs
+cyanidin-3-glucose equivalents

*$P \leq 0.05$

Contrast Pairing: Organic vs. Conventional Blueberries

	Organic	Conventional
TP (mg GAE/g DW)	16.4	16.7
ORAC (μmol TE/g DW)	297	285
Total anthocyanins (mg/g DW)+	15.0	12.2
Delphinidin-3-arabinoside (mg/g DW)+	1.9	1.4
Peonidin-3-glucoside (mg/g DW)+	1.1	0.6
Malvidin-3-glucoside (mg/g DW)+	0.1	1.6

+cyanidin-3-glucose equivalents



Organic vs. Conventional Cranberries: Total Phenols, ORAC, Flavonoids, Anthocyanins

	Organic	Conventional
TP (mg GAE/g DW)	27.5 ± 1.3	26.5 ± 0.6
ORAC (μmol TE/g DW)	451 ± 28	435 ± 20
Total anthocyanins (mg/g DW)+	12.2 ± 3.3	16.0 ± 3.0
cyanidin-3-galactoside (mg/g DW)+	3.1 ± 1.0	4.3 ± 0.6
peonidin-3-glucoside (mg/g DW)+	5.1 ± 1.4	6.8 ± 1.6
malvidin-3-glucoside (mg/g DW)+	0.3 ± 0.1	0.6 ± 0.1*

N = 3 Pairs
+cyanidin-3-glucose equivalents

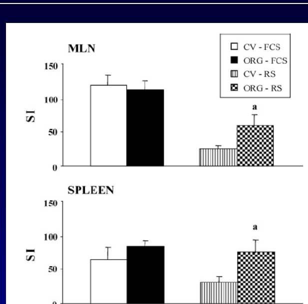
*p≤0.05

Contrast Pairing: Organic vs. Conventional Cranberries

	Organic	Conventional
TP (mg GAE/g DW)	26.5	26.3
ORAC (μmol TE/g DW)	426	427
Total anthocyanins (mg/g DW)+	12.4	12.8
cyanidin-3-galactoside (mg/g DW)+	3.0	3.7
peonidin-3-galactoside (mg/g DW)+	5.3	5.2
malvidin-3-galactoside (mg/g DW)+	0.3	0.4

+cyanidin-3-glucose equivalent

Stimulation Index of Lymphocytes of Mesenteric Lymph Nodes and Spleen of PEM Rats Fed Conventional or Organic Wheat



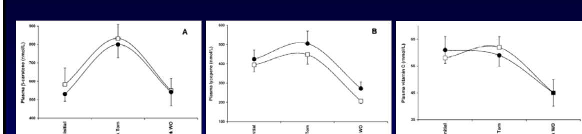
Finamore et al. *J Agric Food Chem* 2004

Concentration of Microconstituents (mg/100 g) in Tomato Purees

microconstituent	conv	org	org vs conv
lycopene	15.57 ± 2.19	13.54 ± 0.60	NS
β-carotene	3.56 ± 1.02	1.71 ± 0.32	NS
vitamin C	22.53 ± 1.07	39.95 ± 0.44	*P* < 0.0001
chlorogenic acid	7.2 ± 0.2	10.6 ± 0.3	*P* < 0.001
rutin	2.30 ± 0.04	9.65 ± 0.28	*P* < 0.0005
naringenin	4.83 ± 0.14	6.18 ± 0.18	*P* < 0.005

Caris-Veyrat et al. *J Agric Food Chem* 2004

Plasma β-Carotene, Lycopene, and Vitamin C in Humans Fed Conventional and Organic Tomato Purees



▪ conventional tomato puree
▫ organic tomato puree

N: 21 females, 21-29 y
Intervention: 100 g/d for 3 wk /3 wk WO

Caris-Veyrat et al. *J Agric Food Chem* 2004

Phytochemicals: From Agricultural Practices to Human Health

Accuse not Nature! She has done her part;

Do Thou but Thine

Milton, ***Paradise Lost***, 1667