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Understanding and Nourishing the Roots of Food Quality

**Phytochemicals:  
From Agricultural Practices to Human Health**

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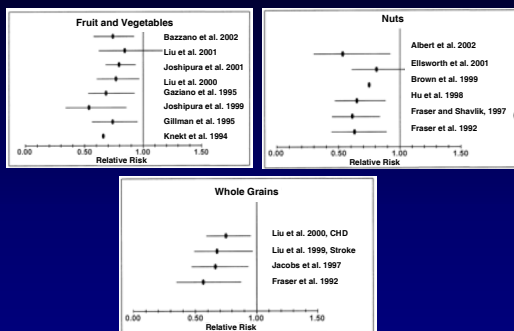
**Are Organic Foods Better for Health?**

**Hypothesis 1:** Phenolics and related secondary plant metabolites are synthesized in response to environmental 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**



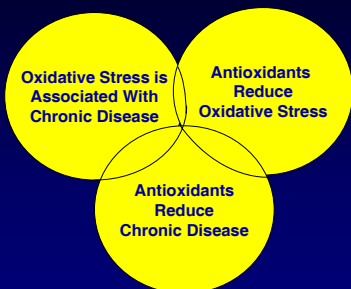
Hu et al. *Am J Clin Nutr* 2003

**Quercetin and Risk of All-Cause Cancer**

Quartile (mg/d)		RR	95% CI
M	F		
-	-	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 | Familial amyotrophic lateral sclerosis |
| Age-related macular degeneration    | Hemorrhagic shock                      |
| Alcoholism                          | Inflammation                           |
| Aluminum neurotoxicity              | Ischemia                               |
| Alzheimer's disease                 | Pancreatitis                           |
| Cancer                              | Parkinson's disease                    |
| Cardiovascular disease              | Porphyria                              |
| Cataracts                           | Rheumatoid arthritis                   |
| Diabetes                            |  |
| Down syndrome                       |  |

## 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

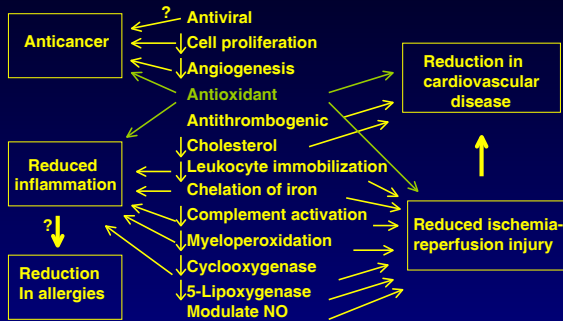
### Simple Phenols

acetophenones      phenolic acids  
 aldehydes          phenylpropanoids  
 benzoquinones      phylacetic acids

### Polyphenolic Compounds

chromones            naftoquinones  
 coumarins           stilbenes  
 flavonoids            xanthenes

## Potential Links Between Polyphenol Mechanisms and Disease



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 <i>JAFAC</i> 2003
Peach, pear	↑ TP, ↑ PPO	Carbonaro et al <i>Food Chem</i> 2001
Peach, pear	↑ TP, ↑ PPO ↑ vC, ↓ vE (peach) ↑ vE (pear)	Carbonaro et al <i>JAFAC</i> 2002
Vaccinium berries, strawberry	↔ quercetin, kampferol, p-coumaric acid	Hakkinen et al <i>Food Res Intl</i> 2000
Chinese cabbage, spinach, Welsh onion, green pepper	↑ TAC, ↑ flavonols ↑ flavones	Ren et al <i>Nippon SKKK</i> 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. Conventional - 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

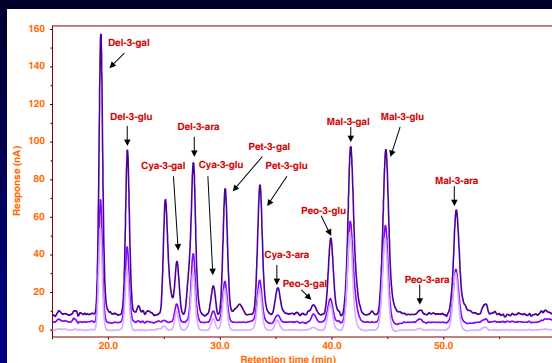
N = 10 pairs



## 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



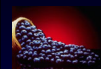
## Organic vs. Conventional Blueberries: Total Phenols, ORAC, Flavonoids, Anthocyanins

	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 ≤ 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

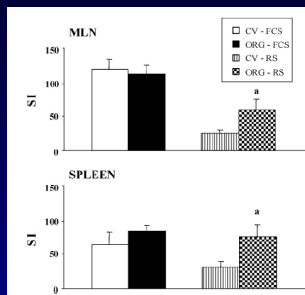


### Contrast Pairing: Organic vs. Conventional Cranberries

	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



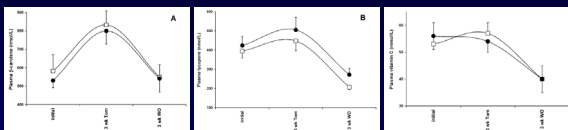
Finamore et al. *J Agric Food Chem* 2004

### 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

