Qualitative and Nutritional Differences Between Organic and Conventionally Produced Processing Tomatoes

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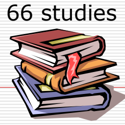
Outline of Presentation

- Reviews on the topic
- Discrepancies in previous approaches
- Commercial Grower Studies
  - 2001 – Stahlbush Island Farms & OR Freeze Dry
  - 2003 – Small Planet Foods
  - 2006 – Campbell's Soup
- Controlled On-Campus Studies
  - 1994-2005 – LTRAS, UC Davis
- Commercial & Controlled Comparison
  - 2004 & 2005 – Submitted to USDA, not funded

Reviews on the Topic

Nutritional Differences between Organic & Conventional

- Lampkin, 1990, Organic Farming.
- Woese et al., 1997, J. Sci. Food & Agric. Reviewed 150 comparisons published between 1924-1994, primarily German literature.
- Worthington, 1998, Alt.Therapies Health & Med. Reviewed 34 publications 1946-1996.
- Bourn and Prescott, 2002, Crit.Reviews in Food Sci & Nutrition. Reviewed 66 studies from 1924-2000, NZ focus.



Reviews on the Topic

Studies Conducted Prior to 2000

- Focus primarily on macronutrients rather than secondary plant metabolites
- Lack of control and diversity of experimental designs in studies does not allow for clear conclusions
- Need for
  - Better experimental design
  - Clearly targeted & appropriate nutrients
  - Consistent approaches

Discrepancies in Previous Approaches

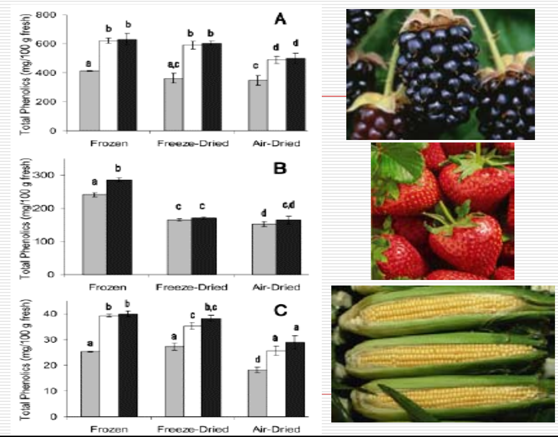
- Controlled university plots vs. "real life" grower fields.
- Lack of information on *production practices* (grower experience, soil type, fertilizer inputs, herbicides and pesticides used, irrigation schemes, weather conditions during growing period etc.)
- *Commodity* grown (cultivar, age of plant/tree, maturity at harvest, harvest date etc.)
- Some commodities obtained from distribution center, retail store or food processing facility will little information on source.

Commercial Grower Studies

- Approach
  - Realistic in terms of scale, management practice and constraints
  - Large scale, more samples possible
  - Robust characterization of ecosystems
- 2001 Stahlbush Island Farms & Oregon Freeze Dry (not tomatoes)
- 2004 Small Planet Foods
- 2006-2008 Campbell's Soup

Stahlbush Island Farms & Oregon Freeze Dry Study (2001)

- Crops grown & processed in Oregon
- Documented soil type, crop age, previous crop, irrigation, chemical application, fertilizer rate & timing
- 3 crops
  - Marion blackberries, strawberries, corn
- 3 production practices
  - organic, sustainable & conventional
- 3 processing methods
  – frozen, freeze-dried and air-dried
- Publication is the most cited ever in J. Agricultural & Food Chemistry, Asami, Hong, Barrett & Mitchell, 2003

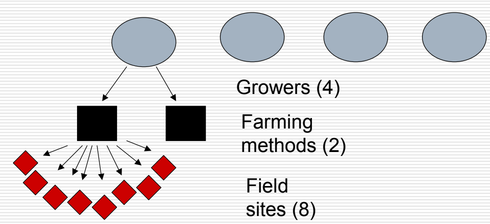


Results & Improvements

- Statistically higher levels of total phenolics in organic and sustainably grown crops
- Ascorbic acid higher in frozen organic and sustainably grown crops
- Improvements
  - Soil types should be matched
  - Desirable to have more than one grower, but should have growers use all production practices
  - More than 1 field replicate desirable
  - Should have a 'fresh' comparison

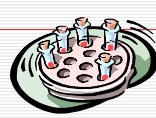
Small Planet Foods Study (2004)

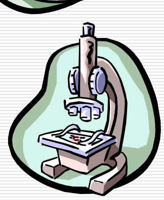
Barrett, Diaz & Weakley – Submitted 4/06



Total samples = 4 x 2 x 8 = 64
Processing Tomatoes

Tomato Quality Attributes Determined





- °Brix
- Bostwick consistency
- pH
- Catsup yield
- Citric acid (T.A.)
- Color (LED, Agtron, L, a, b)
- Ascorbic and Dehydroascorbic acid
- Lycopene
- Total phenolics
- Peelability
- Sensory – 200 consumers

Grower Differences

- Soil fertility - P, K, Mg, Ca, B, etc.
  - Theory – higher nutrient availability in conventional leads to increased plant growth; decreased C allocation to secondary plant metabolites (phenolics, vitamins)
  - N release differs - slow with organic manures/fast with synthetic conventional. Cover crops & microbial pop – more critical in organic
- Water-holding capacity
  - Related to soil texture & type – clay, loam, etc.
  - Limited water availability may lead to stress and increased production of polyphenolics in organic
- Geographical location
- Variety (different in each location)

Campbell's Soup Study (2006-08)

- Processing tomatoes
  - 2 to 5 cultivars, including industry standards
  - 3 (2006) to 8-10 (2008) growers, matched fields
  - 3 year study
  - Soil sampling prior to and at harvest
  - Documentation of production inputs etc.
- Quality attributes & nutrients
  - pH, titratable acidity, SS, color, Bostwick consistency, serum viscosity, peelability
  - Lycopene, Ascorbic acid, total phenolics, specific flavonoids, fiber, individual sugars & pectin

Controlled On-Campus Studies

- Approach
  - Complete control of inputs, irrigation etc.
  - Minimize confounding sources of variability
  - Smaller plots, less real-life
- 1994-2005 Tomato Samples
  - Long Term Research on Agricultural Systems (LTRAS), UC Davis
  - Tomato samples were air dried and stored
  - 2004/05 grant funded analysis by Mitchell (phenolics) and Barrett (lycopene & Vit C)

Correlation of Commercial Grower & On-Campus Controlled Studies

- "Three Year Survey & Controlled Experiments on Nutritive & Quality Characteristics of Organic & Conventionally Grown California Tomatoes"
- Principal Investigators
  - Alyson E. Mitchell, Food Science & Tech
  - Steve Kaffka, LTRAS Director/Agronomy
  - Diane M. Barrett, Dept. Food Science & Tech
  - Tim Hartz, Plant Sciences/Vegetable Crops
  - Ken Shackel, Plant Sciences/Pomology
  - Richard Plant, Agronomy/Biostatistics
- Submitted to USDA Integrated Organic Program in 2004 and 2005 – not funded

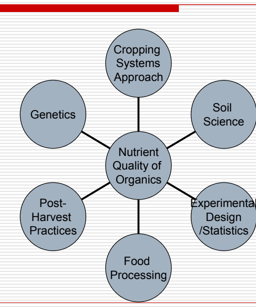
Experimental Design
USDA Integrated Organic Program Proposal

- Three year survey of grower fields
  - 8 fields each of organic & conventional
  - 4 sampling locations per field
  - Soil, plant and moisture sampling
- Research micro-plots at LTRAS
  - 4 levels of Nitrogen application
  - 4 levels of water stress
- "Quality" analysis – pH, titratable acidity, SS, Bostwick, color
- "Nutrients" analysis – ascorbic, lycopene, flavonoids and alkaloids

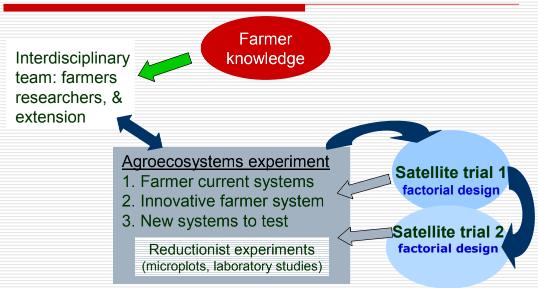
Experimental Designs - *Desired Components*

- Broader *"systems" approach*, with nested factorial sub-plots to study various treatments
- Years of *experience* in organic & conventional
- Representative, well-characterized and *matched soil* types. Soil sampling prior to starting.
- Cultivation practices *documented* and consistent over 5 years or longer
- *Documented production inputs* – fertilizer, pesticides, herbicides, etc.
- Use different cultivars, different growers, different regions and more than one location sampled per field

Multi-Disciplinary Approach
Understanding effects of cultural practices on food quality



Long-term Systems Experiment: Design and Managment



Drinkwater, modified from Snapp, 2003