The Role of Food Science & Technology in Dietary Guidelines

Roger Clemens, DrPH

IFT, President (2011-2012)
Member, 2010 Dietary Guidelines Advisory Committee
Chief Scientific Officer, Horn
Adjunct Professor, Pharmacology and Pharmaceutical Sciences, USC School of Pharmacy
Where is the food scientist?

- What is the process?
- What is the role of a food scientist? a nutritionist? a dietitian? a physician? a public health specialist?
- What are the challenges of a food scientist?
- What are the opportunities for a food scientist?
- Should these challenges and opportunities impact the education and training of future food scientists?
The Process

- The Committee
- The Analysis
  - Questions from literature
  - Questions from the public (> 2000 comments)
  - Questions from the Committee (~130)
  - Questions from DG 2005
- The Policy
  - Committee report
  - Public comment period (30 d)
  - Consumer meetings
  - Peer review within the agencies
  - Writing task force
- The Transparency
## Conclusion Statement Grading Table

<table>
<thead>
<tr>
<th>Strength of Evidence</th>
<th>Grade I Good/ Strong</th>
<th>Grade II Fair</th>
<th>Grade III Limited/ Weak</th>
<th>Grade IV Expert Opinion</th>
<th>Grade V Not Assignable</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Quality</strong></td>
<td>Studies of strong design for question</td>
<td>Studies of strong design for question</td>
<td>Studies of weak design for answering question, OR Inconclusive findings due to design flaws, bias or execution problems</td>
<td>No research studies available; Based on usual practice, expert consensus, clinical experience, opinion, or extrapolation from basic research</td>
<td>No evidence that pertains to question being addressed</td>
</tr>
<tr>
<td>Scientific rigor/validity</td>
<td>Free from design flaws, bias and execution problems</td>
<td>With minor methodological concerns, OR Only studies of weaker design for question</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Considers design and execution</td>
<td>Findings generally consistent in direction and size of effect or degree of association, and statistical significance with minor exceptions at most</td>
<td>Inconsistency among results of studies with strong design, OR Consistency with minor exceptions across studies of weaker design</td>
<td>Unexplained inconsistency among results from different studies OR single study unconfirmed by other studies</td>
<td>Conclusion supported solely by statements of informed nutrition or medical commentators</td>
<td>NA</td>
</tr>
<tr>
<td>Consistency of findings across studies</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
# Conclusion Statement Grading Table

<table>
<thead>
<tr>
<th>Strength of Evidence</th>
<th>Grade I</th>
<th>Grade II</th>
<th>Grade III</th>
<th>Grade IV</th>
<th>Grade V</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Good/Strong</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Fair</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Limited/Weak</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Expert Opinion</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Not Assignable</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

## Quantity
- Number of studies
- Number of subjects in studies

| One to several good quality studies |
| Large number of subjects studied |
| Studies with negative results have sufficiently large sample size for adequate statistical power |
| Several studies by independent investigators |
| Doubts about adequacy of sample size to avoid Type I and Type II error |
| Limited number of studies |
| Low number of subjects studied and/or inadequate sample size within studies |
| Unsubstantiated by published research studies |
| Relevant studies have not been done |

## Clinical Impact
- Importance of studied outcomes
- Magnitude of effect

| Studied outcome relates directly to the question |
| Size of effect is clinically meaningful |
| Significant (statistical) difference is large |
| Some doubt about the statistical or clinical significance of the effect |
| Studied outcome is an intermediate outcome or surrogate for the true outcome of interest |
| OR |
| Size of effect is small or lacks statistical and/or clinical significance |
| Objective data unavailable |
| Indicates area for future research |

## Generalizability

| Studied population, intervention and outcomes are free from serious doubts about generalizability |
| Minor doubts about generalizability |
| Serious doubts about generalizability due to narrow or different study population, intervention or outcomes studied |
| Generalizability limited to scope of experience |
| NA |
The Focus

- Primary Public Health Issues:
  - Energy and Physical Activity
    - Obesity among Children & Adults
- Other Public Health Issues:
  - Cardiovascular (Heart) Disease
  - Hypertension (Elevated Blood Pressure)
  - Diabetes (Elevated Blood Glucose)
  - Cancer (Diet-related, e.g., Obesity, Insufficient folic acid)
Dietary Intakes in Comparison to Recommended Intake Levels or Limits

**Intake as percent of goal or limit**

<table>
<thead>
<tr>
<th>Intake</th>
<th>Goal</th>
<th>Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Whole Grains</td>
<td>15%</td>
<td>59%</td>
</tr>
<tr>
<td>Vegetables</td>
<td>42%</td>
<td>52%</td>
</tr>
<tr>
<td>Fruits</td>
<td>42%</td>
<td>61%</td>
</tr>
<tr>
<td>Milk</td>
<td>40%</td>
<td>56%</td>
</tr>
<tr>
<td>Oils</td>
<td>42%</td>
<td>75%</td>
</tr>
<tr>
<td>Fiber</td>
<td>15%</td>
<td>280%</td>
</tr>
<tr>
<td>Potassium</td>
<td>42%</td>
<td>242%</td>
</tr>
<tr>
<td>Vitamin D</td>
<td>42%</td>
<td>281%</td>
</tr>
<tr>
<td>Calcium</td>
<td>42%</td>
<td>200%</td>
</tr>
<tr>
<td>Calories from SoFAS</td>
<td>42%</td>
<td>229%</td>
</tr>
<tr>
<td>Added sugars</td>
<td>42%</td>
<td>158%</td>
</tr>
<tr>
<td>Solid fats</td>
<td>42%</td>
<td>250%</td>
</tr>
<tr>
<td>Refined grains</td>
<td>42%</td>
<td>300%</td>
</tr>
<tr>
<td>Sodium</td>
<td>42%</td>
<td>300%</td>
</tr>
<tr>
<td>Saturated fat</td>
<td>42%</td>
<td>300%</td>
</tr>
</tbody>
</table>
Role of the Food Scientist

- Perceived “corner”
  - Food safety
  - Other

- Practical “placement”
  - Broad application
  - Transition of food science & technology (including agriculture) to wellness (healthy America)

- Preparation
  - Reach beyond the basics
  - Broad spectrum of education, training and experience
  - Consider consumer communication and behavioral science
The Concerns

- Overnutrition
  - Energy → change dietary patterns and physical activity (lifestyle, behavior)
  - Sodium → 1,500 mg/d (at-risk populations)
  - Saturated Fatty → < 10% total energy (replace with MUFA and PUFA)
  - Added sugars, refined grains → contribute excess energy
The Concerns

- **Undernutrition**
  - **Shortfall Nutrients**
    - Vitamins A, C, D, E and K, plus choline, calcium, magnesium, potassium and dietary fiber
  - **Public Health Concern**
    - Vitamin D – many children and majority of adults not meet AI → consume vitamin D-rich foods
    - Calcium – many children and majority of adults not meet AI (not systematic review due to IOM panel)
    - Potassium – 3-6% adults meet AI (women & men, respectively)
    - Dietary Fiber - < 3% exceed AI

- **Selected Population Subgroups**
  - Folic acid – Adolescent females and women of reproductive capacity
  - Iron – Adolescent females and women of reproductive capacity
  - Vitamin B$_{12}$ – Persons over age 50 years
The Challenges of the Food Scientist

1. Food supply chain
2. Sodium reduction
3. Energy-appropriate portions
   • Consider impact on QSR, Food Service
   • Consider impact on beef, poultry, fish
4. Saturated fat replacement (MUFA/PUFA) and product stability
5. Nutrient-dense
6. Whole Grains (vs Dietary Fiber) vs Refined Grains
7. Fruit/vegetables, nuts, seeds, fluid dairy
Agricultural Challenges (to meet 2010 DG within next 5 years)

- 8.9 million more acres of cropland would be needed to support vegetable production (2002 statistic) → 10.3 million more acres (2015 projection)
- 4.1 million more acres of cropland would be needed to support fruit production (2002 statistic) → 4.7 million more acres (2015 projection)
- In general, need nearly 2% increase in total US cropland (2002 statistic) → more than 2.3% increase in total US cropland (2015 projection) or about 3% increase in harvested cropland (about 320 million acres; 1997 acreage)
- 107.7 billion additional pounds of fluid milk and milk products are needed (an increase of 66% - impact on number of dairy cows, feed grains, and “grazing” acreage) → 124.6 billion additional pounds (2015 projection) → nearly 80% increase (cows, feed grains, grazing acreage)

1 gallon of milk requires **880** gallons of water.

Milk requires water for raising and grazing cattle, and bottling and processing.

1 pound of corn requires **108** gallons of water.

Annual worldwide corn production uses 19.4 trillion cubic feet of water.

Corn production accounts for **8%** of global water use for the planet’s total agricultural crop production.

1 pound of beef requires **1,799** gallons of water.

**6.6** pounds of grain for feed plus irrigation water.

**36.2** pounds of roughage or grasses for feed plus irrigation water.

**18.6** gallons of additional water for drinking and processing.

1 pound of wheat requires **132** gallons of water.

Annual worldwide wheat production needs about 27.9 trillion cubic feet of water.

Wheat production accounts for 12% of global water use for the planet’s total agricultural crop production.

1 pound of rice requires **449** gallons of water.

Annual worldwide rice production needs about 47.7 trillion cubic feet of water.

Rice production accounts for 21% of global water use for the planet’s total agricultural crop production.
Dietary Sodium

- A strong body of evidence has documented that in adults, as sodium intake decreases, so does blood pressure.
- A moderate body of evidence has documented that as sodium intake decreases, so does blood pressure in children, birth to 18 years of age.
- The reduction from 2,300 mg to 1,500 mg per day should occur gradually over time. [about 750 mg/1000kcal]
### Sodium Reduction is a Priority

<table>
<thead>
<tr>
<th>Company</th>
<th>Degree of Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Campbell’s</td>
<td>25% - Pepperidge Farm by Feb 2011&lt;br&gt;25 to 45% - Already implemented in soups&lt;br&gt;32% - Already achieved in V8 juice over 8 years</td>
</tr>
<tr>
<td>ConAgra Foods</td>
<td>20% - Across portfolio by 2015&lt;br&gt;15% - Healthy Choice soups</td>
</tr>
<tr>
<td>General Mills</td>
<td>20% - Across multiple categories by 2015</td>
</tr>
<tr>
<td>Heinz</td>
<td>15% - Tomato ketchup&lt;br&gt;20% - Bagel Bites</td>
</tr>
<tr>
<td>Kellogg’s</td>
<td>24% - Already achieve since 2001</td>
</tr>
<tr>
<td>Kraft Foods</td>
<td>10% - Across categories over 2 years</td>
</tr>
<tr>
<td>Nestlé SA</td>
<td>&lt; 100 mg/100 kcal</td>
</tr>
<tr>
<td>PepsiCo</td>
<td>25% - Key global snack brands by 2015</td>
</tr>
<tr>
<td>Sara Lee</td>
<td>20% - Implemented over 5 years</td>
</tr>
</tbody>
</table>

© 2012 Institute of Food Technologists
Challenges - Sodium

Salt (NaCl) has multiple unique functions

- Taste
- Enhances other flavors
- Reduces bitterness
- Microbial safety
- Promotes development of color in cooked meat products, cereals, and bread
- Controls fermentation in cheese and related products
- Minimizes ice-crystal formation in frozen products
- Promotes firm texture in processed meats
- Provides binding strength in meats
- Improves tenderness
- Reduces cooking loss in meats
- Strengthens gluten in bread dough for uniform texture, grain and dough strength

Other sodium salts
- Bicarbonate – leavening in baking
- Ascorbate – vitamin C source
- Lactate and sorbate – preservation
- MSG – umami taste
- Citrate – pH regulation

Regulations
- Food safety → preservation

© 2012 Institute of Food Technologists
Stepwise Process for Salt (Sodium) Reduction in Foods

*Evaluation with adjustment through rulemaking:
  - Consumer acceptance/taste-flavor issues
  - Technological feasibility (food safety, shelf life, physical properties)
  - New technologies
  - Monitoring of intake
  - Monitoring of changes in salt taste preference
  - Monitoring of sodium in food supply/food composition
  - Monitoring of use and consequences of any labeling
  - Monitoring of industry activities
  - Monitoring of related concerns; for example, iodine and potassium status
Dietary Contributions of Sodium

Food Categories; Percent of Total Daily Sodium

- Meat, meat alternatives: 15.5%
- Mixed dishes: 44%

**Meat, Meat Alternatives**

- Chicken: 4%
- Cheese: 2%
- Eggs: 2%
- Bacon/Sausage: 2%
- Beef: 2%

**Mixed Dishes**

- Ground beef: 16%
- Rolls: 5%
- Cheese: 3%
- Condiments: 3%
- Mexican entrees: 2%
- Hamburger/cheese burgers: 2%
- Pizza with meat: 2%
- Cold cuts, bread, cheese, hot dogs, rolls, bacon/sausage, condiments, chicken, fish, ham: 1%

NHANES, 2003-2006
## Sodium Density of Foods

<table>
<thead>
<tr>
<th>Source of Food</th>
<th>Sodium Density (mg/1,000 kcal)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Home</td>
<td>1,422</td>
</tr>
<tr>
<td>Away from Home</td>
<td>1,825</td>
</tr>
<tr>
<td>Restaurants</td>
<td>1,925</td>
</tr>
<tr>
<td>QSR/Pizza Restaurants</td>
<td>1,805</td>
</tr>
<tr>
<td>School</td>
<td>1,629</td>
</tr>
<tr>
<td>Other</td>
<td>1,466</td>
</tr>
</tbody>
</table>

NHANES, 2003-2006

Aspirational target: <750 mg/1000 kcal
QSRs Lower Sodium

- Thin “buns” (fewer calories [~100 kcal vs ~150-200]; less sodium [~150 mg vs ~280 mg])
- French fries (need to meter per batch; eliminate “cook” discretion; e.g., McDonalds small $\approx 160$ mg/serving; or about 600 mg/1,000 kcal)
- Hash browns (portion control) with added onions/garlic/spices etc and EV olive oil (not butter or margarine)
- “Breading” spice blends (work with research chefs)
- Condiments (many lower Na products now available)
Sodium Reductions

- Broad commitment to decrease sodium across multiple categories
- Competition among companies
- Focus is on major contributors (think volume in food supply)
- Decreases will take time
- The DGAC goal over 50% reduction will require radical changes in food intake patterns
- Need to be vigilant for unintended consequences, e.g., safety, iodine status (pending IFT-FDA report), decreased use of bitter foods/components (remember chocolate)
The Outcomes

- **Foods and Nutrients to Increase**
  - Fluid milk (nonfat, low-fat) and milk products
  - Vegetables (dark green, orange) and Fruit
  - Whole grains
  - Protein foods (seafood, meat, poultry, eggs, beans, peas, soy products, nuts and seeds)
  - Oils (PUFA, MUFA $\rightarrow$ EFA + vitamin E)
- technology / agriculture within next 5 years $\rightarrow$ ↓ SFA and ↑ MUFA and PUFA (including DHA, EPA)
Technologies → Personal Health

- Saturated Fatty Acids
  - Stearic acid: non-atherogenic, possible substitution of tFAs; sources include cocoa butter, and new grain cultivars (e.g., corn, soy)

- Trans Fatty Acids
  - Ruminant sources not likely a health issue

- Plant-based Foods → good tasting + good nutrition (beyond basics) (total diet pattern)
  - Legumes (e.g., chickpeas, soy)
  - Fruits and Vegetables (color, including white is good)
  - Nuts and Seeds (e.g., almonds, walnuts)
  - Whole grains (e.g., broad applications)
Opportunities – Added Sugars

▪ Sweetener alternatives
  • High intensity sweeteners – aspartame, etc
  • Natural peptide sweeteners – stevia, luo han guo
  • Sucralose
  • Sugar alcohols (careful with side effects)
  • Taste modifiers

▪ Combinations usually required to achieve
  • Sweetness profile like sugar
  • Stability
  • Bulk/volume
  • Functionality
Opportunities – Added Sugars

▪ Smaller portions
  • e.g., 8 oz cans → 4 oz cans

▪ No added sugar/diet products
  • e.g., European fruit juice initiative (2nd amendment to Directive 2001/112/EC) → EU to a) ban “added” sugar from fruit juices (although “added” sugar and honey permitted in nectars), b) count tomatoes as a fruit

▪ Gradually decrease added sugar (need sensory research)
Challenges – Added Sugars

- Consumer distraction and confusion with “HFCS”, “natural”
- Sports/energy drinks
- No added sugar/sugar-free claims not possible with current peptide sweeteners
- Tolerance of sugar alternatives can limit applicability
  - e.g., polyols (excess consumption → GI distress)
Opportunities – Refined Grains

- Desserts in moderation
  - Promotional messages
  - Smaller portion sizes

- Replace with fiber
  - Functionality critical
  - Stability essential

- Gradually replace refined grain with whole grain

- Introduce whole grain options
  - Communicate positive value of whole grain content
Opportunities – Refined Grains

- Address consumer concerns with whole grain flour
  - Color – while, whole wheat flour
  - Texture – fine milling
  - Taste – modulators
  - Stability – processing/packaging
  - Tradition
  - Cost
Challenges – Refined Grains

- Inconsistent nomenclature
  - Enriched flour/refined flour (see regulations)
- Enriched flour not quantified on product label
- Ability to communicate health benefits of whole grains in products with < 51% whole grains
- Unintended consequences
  - Increased sugars for taste
  - Decreased folic acid from enriched grains
Opportunities – Solid Fats

- Indigestible fats
- Saturated and unsaturated fat blends
- Inter-esterified fats permit further reductions
- New plant oils
  - Conventional breeding/hybridization, biotechnology
- Coatings which decrease fat retention in fried foods
Challenges – Solid Fats

- Indigestible fats not well tolerated
- Nomenclature confusing
  - Solid, saturated, cholesterol-raising
- Time to get from crop to market
  - ~ 6 years for high oleic sunflower oil
- Unintended consequences
  - Decreased n-3 (ALA) intake if high oleic soy displaces regular soy oil
Challenge: Fiber “Functional” Classification

- Current: **Dietary** and **Functional**
  - **Dietary fiber**: non-digestible carbohydrates and lignin that are intrinsic and intact in plant cell walls.
  - **Functional Fiber**: isolated, non-digestible carbohydrates that have beneficial physiological effects in humans.
  - **Total Fiber**: the sum of *dietary fiber* and *functional fiber*

# Variable Composition

## Percent

<table>
<thead>
<tr>
<th>Grain/Component</th>
<th>Germ *</th>
<th>Endosperm (flour)</th>
<th>Bran *</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat</td>
<td>3 ± 0.5</td>
<td>83 ± 1.0</td>
<td>14 ± 0.5</td>
</tr>
<tr>
<td>Corn</td>
<td>11 ± 1.5</td>
<td>82 ± 1.5 (e.g., grits, meal, flour)</td>
<td>7 ± 0.5</td>
</tr>
<tr>
<td>Oats</td>
<td></td>
<td>67 ± 0.5</td>
<td>33 ± 0.5</td>
</tr>
<tr>
<td>Rice</td>
<td>2.5 ± 0.5</td>
<td>90 ± 1.0</td>
<td>7.5 ± 0.5</td>
</tr>
</tbody>
</table>

* Germ and Bran provide > 80% of phenolics, even though these components represents a small percentage of the total grain. Endosperm represents the large majority of whole grains, this is the main source of digestible carbohydrates (energy) and the main source of white flours.

Calculations from published data (peer reviewed and textbook) by Deirdre Ortiz Ph.D., 2010
Whole Grains: The Benefit is in the Fiber

Fiber:
- Is a nutrient found within foods?
- Is found on the Nutrition Information panel?
- Its co-passengers in bran are potentially beneficial phytonutrients (think balance)
- Consistently found as a nutrient of need in Dietary Guidelines Recommendations

Whole Grains
- Are often used as ingredients in other foods, such as cereal and breads
- Is found in the ingredient list

Excellent Source of Fiber

© 2012 Institute of Food Technologists
Balance of Antioxidants and Reactive Species

- Arachidonic acid metabolism
- Phyagocytes
- Mitochondrial respiration
- Xanthine oxidase
- Other sources
- Antioxidants
  - Peroxiredoxins
  - Glutathione/glutathione persoxidase system
  - SOD, Catalase
  - Iron chelators (e.g., lactoferrin)
  - Blood components, e.g., Albumin, Ceruloplasmin, Hemoplexin, Haptoglobin, Transferrin
- Diet-derived Antioxidants (e.g., polyphenols?)
- POLYPHENOLS

ROS – reactive oxygen species
SOD – superoxide dismutase

Halliwell B. Arch Biochem Biophys 2008;476:107-12
## Methodology Comparison

<table>
<thead>
<tr>
<th>Total Phenolics</th>
<th>ORAC</th>
<th>CAA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wild blueberry</td>
<td>Wild blueberry</td>
<td>Wild blueberry</td>
</tr>
<tr>
<td>Blackberry</td>
<td>Cranberry</td>
<td>Pomegranate</td>
</tr>
<tr>
<td>Pomegranate</td>
<td>Strawberry</td>
<td>Blackberry</td>
</tr>
<tr>
<td>Cranberry</td>
<td>Blackberry</td>
<td>Strawberry</td>
</tr>
<tr>
<td>Blueberry</td>
<td>Cherry</td>
<td>Blueberry</td>
</tr>
<tr>
<td>Plum</td>
<td>Plum</td>
<td>Raspberry</td>
</tr>
<tr>
<td>Raspberry</td>
<td>Blueberry</td>
<td>Plum</td>
</tr>
<tr>
<td>Strawberry</td>
<td>Apple</td>
<td>Cherry</td>
</tr>
<tr>
<td>Red Grape</td>
<td>Pomegranate</td>
<td>Apple</td>
</tr>
<tr>
<td>Apple</td>
<td>Orange</td>
<td>Red Grape</td>
</tr>
<tr>
<td>Cherry</td>
<td>Red Grape</td>
<td>Peach</td>
</tr>
<tr>
<td>Pear</td>
<td>Peach</td>
<td>Lemon</td>
</tr>
<tr>
<td>Pineapple</td>
<td>Lemon</td>
<td>Pear</td>
</tr>
<tr>
<td>Peach</td>
<td>Grapefruit</td>
<td>Grapefruit</td>
</tr>
<tr>
<td>Grapefruit</td>
<td>Pear</td>
<td>Peach</td>
</tr>
<tr>
<td>Nectarine</td>
<td>Nectarine</td>
<td>Nectarine</td>
</tr>
<tr>
<td>Mango</td>
<td>Watermelon</td>
<td>Watermelon</td>
</tr>
<tr>
<td>Kiwifruit</td>
<td>Avocado</td>
<td>Kiwifruit</td>
</tr>
<tr>
<td>Orange</td>
<td>Kiwifruit</td>
<td>Mango</td>
</tr>
<tr>
<td>Banana</td>
<td>Mango</td>
<td>Pineapple</td>
</tr>
<tr>
<td>Lemon</td>
<td>Pineapple</td>
<td>Orange</td>
</tr>
<tr>
<td>Avocado</td>
<td>Banana</td>
<td>Lemon</td>
</tr>
<tr>
<td>Cantaloupe</td>
<td>Honeydew</td>
<td>Nectarine</td>
</tr>
<tr>
<td>Honeydew</td>
<td>Cantaloupe</td>
<td>Honeydew</td>
</tr>
<tr>
<td>Watermelon</td>
<td>Banana</td>
<td>Cantaloupe</td>
</tr>
</tbody>
</table>

Wolfe et al., J Agric Food Chem 2008;56:8418-26
Pharmanutrition

Plasma Concentration-Time Curve for Total Radioactivity
After Oral 25mg (110 µmol)

Absorption: ~ 70%
Plasma half-life: 9.2 ± 0.6 hr
Plasma detection (parent molecule): < 5 ng/mL

Urine recovery (%): 70.5 ± 10.5
Fecal recovery (%): 12.7 ± 14.9

Walle T et al., Drug Metabol Dispos 2004;32:1377-82

- Neem (Azadirachta indica) – used on crops to control pests on crops and inhibit CO$_2$ emissions from urea-amended soil (may be reproductive inhibitor, although approved by EPA)
- Nicotine sulfate – used for insect control; not safe for humans (potent neurotoxin) (limited availability)
- Pyrethrum – insecticide (e.g., mosquitoes and similar insects) from Chrysanthemum seeds (potent paralytic and neurotoxin)
- Rotenone – insecticide, acaricide (spiders, ticks, mites), piscicide (fish); from plants (Lonchorcarpus or Derris); inhibits cellular respiration; moderate toxin (lethal at 300-500 mg/kg bw; NOAEL ~ 0.4 mg/kg bw/d) (comparable to LD$_{50}$ caffeine – aspirin)
- Sabadilla – insecticide from lily-like plant in Mexico and Central America; stomach poison; risk assessment incomplete

http://organic.lovetoknow.com/Permitted_Chemicals_List_for_Organic_Farming
Accessed January 23, 2012

Some chemicals are allowed in organic farming.

Sabadilla lily

© 2012 Institute of Food Technologists
**Think Nutrition: Organic vs Conventional**

Comparison of content of nutrients and other nutritionally relevant substances in organically and conventionally produced crops as reported in satisfactory-quality studies

<table>
<thead>
<tr>
<th>Nutrient category</th>
<th>No. of studies</th>
<th>No. of comparisons</th>
<th>Standardized difference</th>
<th>P</th>
<th>Higher concentrations in organic or conventional crops?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrogen</td>
<td>17</td>
<td>64</td>
<td>6.7 ± 1.9</td>
<td>0.003</td>
<td>Conventional</td>
</tr>
<tr>
<td>Vitamin C</td>
<td>14</td>
<td>65</td>
<td>2.7 ± 5.9</td>
<td>0.84</td>
<td>No difference</td>
</tr>
<tr>
<td>Phenolic compounds</td>
<td>13</td>
<td>80</td>
<td>3.4 ± 6.1</td>
<td>0.60</td>
<td>No difference</td>
</tr>
<tr>
<td>Magnesium</td>
<td>13</td>
<td>35</td>
<td>4.2 ± 2.3</td>
<td>0.10</td>
<td>No difference</td>
</tr>
<tr>
<td>Calcium</td>
<td>13</td>
<td>37</td>
<td>3.7 ± 4.8</td>
<td>0.45</td>
<td>No difference</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>12</td>
<td>35</td>
<td>8.1 ± 2.6</td>
<td>0.009</td>
<td>Organic</td>
</tr>
<tr>
<td>Potassium</td>
<td>12</td>
<td>34</td>
<td>2.7 ± 2.4</td>
<td>0.28</td>
<td>No difference</td>
</tr>
<tr>
<td>Zinc</td>
<td>11</td>
<td>30</td>
<td>10.1 ± 5.6</td>
<td>0.11</td>
<td>No difference</td>
</tr>
<tr>
<td>Total soluble solids</td>
<td>11</td>
<td>29</td>
<td>0.4 ± 4.0</td>
<td>0.92</td>
<td>No difference</td>
</tr>
<tr>
<td>Copper</td>
<td>11</td>
<td>30</td>
<td>8.6 ± 11.5</td>
<td>0.47</td>
<td>No difference</td>
</tr>
<tr>
<td>Titratable acidity</td>
<td>10</td>
<td>29</td>
<td>6.8 ± 2.1</td>
<td>0.01</td>
<td>Organic</td>
</tr>
</tbody>
</table>

1 Nutrient categories are listed by numeric order of the included studies.
2 All values are means ± SEs (robust).

Dangour AD et al., Am J Clin Nutr 2009;90:680-5
### Comparative Agriculture Practices

Nutrient content (on a fresh basis) of tomatoes obtained with three different agricultural practices

<table>
<thead>
<tr>
<th>Production Type</th>
<th>Moisture (%)</th>
<th>Crude Protein (%)</th>
<th>Ash (%)</th>
<th>Lycopene (mg %)</th>
<th>Vitamin C (mg %)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organic</td>
<td>92.0 (0.25)</td>
<td>1.46 (0.04)</td>
<td>0.065 (0.006)</td>
<td>3.72 (0.55)</td>
<td>11.8 (0.8)</td>
</tr>
<tr>
<td>Conventional</td>
<td>92.6 (0.15)</td>
<td>1.05 (0.02)</td>
<td>0.049 (0.005)</td>
<td>4.89 (0.18)</td>
<td>21.4 (1.6)</td>
</tr>
<tr>
<td>IPM</td>
<td>92.2 (0.40)</td>
<td>1.14 (0.018)</td>
<td>0.038 (0.005)</td>
<td>3.54 (0.20)</td>
<td>21.2 (3.0)</td>
</tr>
</tbody>
</table>

*P value of model* NS 0.0001 0.0044 0.0238 0.0056

<table>
<thead>
<tr>
<th>Production Type</th>
<th>β-carotene (mg%)</th>
<th>Salicylic Acid (mg%)</th>
<th>Cd (ppb)</th>
<th>Pb (ppb)</th>
<th>Cu (ppb)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organic</td>
<td>0.33 (0.04)</td>
<td>0.074 (0.005)</td>
<td>33.0 (6.3)</td>
<td>37.8 (15)</td>
<td>0.49 (0.03)</td>
</tr>
<tr>
<td>Conventional</td>
<td>0.30 (0.02)</td>
<td>0.046 (0.003)</td>
<td>2.0 (1.7)</td>
<td>3.4 (1.9)</td>
<td>0.46 (0.05)</td>
</tr>
<tr>
<td>IPM</td>
<td>0.28 (0.04)</td>
<td>0.021 (0.003)</td>
<td>21.3 (9.2)</td>
<td>1.6 (1.2)</td>
<td>0.65 (0.05)</td>
</tr>
</tbody>
</table>

*P value of model* 0.5952 0.0001 0.0101 0.0107 0.0171

Values are mean (SE); n = 10 for each type of products except for salicylate (organic = 7) and vitamin C (n=6); For all the tested phytochemicals, the analytical methods never detected samples with concentrations higher than the LOD.

Rossi F et al., Eur J Nutr 2008;47:266-72
Organic vs Conventional Summary (separate review)

- Limited studies were inconsistent relative to nutritional quantitative and qualitative differences between organic and conventionally produced food products.
- Evidence suggests that it is premature to conclude that the nutritional value and purported health benefits of organic foods are better than those produced through conventional agricultural practices.
Processed

- Pertinent to food technology (courtesy of USDA)
  
  - Processed food
    - any raw agricultural commodity that has been subject to washing, cleaning, milling, cutting, chopping, heating, pasteurizing, blanching, cooking, canning, freezing, drying, dehydrating, mixing, packaging, or other procedures that alter the food from its natural state
    - may include the addition of other ingredients to the food, such as preservatives, flavors, nutrients, and other food additives or substances approved for use in food products, such as salt, sugars, and fats
    - may reduce, increase, or leave unaffected the nutritional characteristics of raw agricultural commodities
  
  - Minimally processed food
    - retains most of its inherent physical, chemical, sensory and nutritional properties
    - many minimally processed foods are as nutritious as the food in its unprocessed form
Healthy Eating & Maxed Mom

Americans are looking at one meal at a time

- Increased efforts to eat more healthfully
- More understanding that plant-based meals are healthful
- Supermarkets are featuring fresh produce and freshly made food areas
- Restaurants, QSRs, in-store venues are offering more plant-based individual foods and meals
- Creative cooking with whole grains, fruits and vegetables, cooked dry beans and peas, nuts and seeds

Mintel. Attitudes Towards Food. May 2009
Technical Opportunities and Challenges

Opportunities

• Reduce total energy intake
• Shift food intake pattern
• Reduce intake of negative
  – Portion control
  – Consumption frequency
  – Alternative promotion
• Reformulation
  – Gradual changes for consumer acceptance
  – Introduce line extensions, e.g., low fat milk products (delivery vehicles of “inadequate” nutrients)

Challenges

• Reformulation costs
  – Product development (ingredient supply)
  – Consumer acceptance (needs research)
  – Concept to Commercialization
  – Resource reallocation (e.g., may exceed $0.5 MM / product)
• Ingredient costs
• Distribution costs
• Regulatory statutes and costs (see FDA Food Safety Modernization Act)
• Consumer demands and timelines incongruent with technology

Courtesy of Robbie Burns, Nutrition Implications LLC, October 2010
Conclusion

To achieve proposed dietary guidelines and transitions

- Significant changes in agriculture
- Significant changes in food science development and applications
- Significant changes in food intake patterns
- Significant changes in lifestyle