Accelerating the Path to Improving Public Health through Food Based Solutions: Leveraging Collaborations between Government and Academia to Create a More Convenient & Healthful Food Supply

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National Coalition for Food and Agriculture Research
Hill Seminar Series, May 12, 2017
Meeting Today’s Health Challenges with Diet

Heart disease, stroke, and diabetes

Overweight and obesity among adults

Increasing mean age of population

Population 75y & older will ↑ 12% by 2050

Annual Per Capita Healthcare Costs by Age

- US
- Germany
- UK
- Sweden
- Spain
Physiological effects from food are derived from both nutrients and non-nutrients.
Dietary bioactive compounds are part of the foods we eat.

**Macronutrients**
Carbohydrates, Lipids, Protein, (Fiber)

- Catechins
- Polyphenols
- Anthocyanins
- CLA
- ACE peptides
- Lecithin
- Carotenoids

**Micronutrients**
Vitamins, Minerals

- ACE Peptides
- Omega-3 FA
- Chlorophyll
- Phenolics
- Phytosterols
- Phenolic Acids
- Anthocyanins
- Carotenoids
- Phytoestrogens
- Flavonones
- Flavonoids
- Phenolic Acids
- Carotenoids
- Sulfides & Thiol Compounds

**Aroma**

**Taste**

**Texture**
Phytonutrients and Health
DG 2015: A healthy food pattern should include

• A variety of dark green, red and orange vegetables, legumes (beans and peas), starchy, and other fruits

• Grains, at least half of which are whole grains

• Fat-free or low-fat dairy, including milk, yogurt, cheese, and/or fortified soy beverages

• A variety of protein foods, including seafood, lean meats and poultry, eggs, legumes, nuts, seeds, and soy products

• MUFA and PUFA rich oils
DG 2015: Translation to Consumers through Multiple Levels

Policy Translation

Consumer Translation

Consumer Food Options
Some Challenges and Limitations with the DG?

- Focus on nutrients and food groups
- Phytochemicals not considered

- Are we getting proper translation to the grocery store for consumers?
How do we better deliver nutrition and health in a world where taste and price are the most critical factors in buying food and beverages?

How much of an impact do the following have on your decision to buy foods and beverages? (% Rating 4 to 5 on 5-point scale, from No Impact to A Great Impact)

IFIC 2016 Food & Health Survey

2016 n=1,003
Two key and related life science disciplines are required to make advances in food, health and wellness.

• Food Science – Defining “What food is”
  – Investigates technical aspects of food composition, processing and consumption
  – “From farm to fork”

• Nutrition Science – Defining “What food does”
  – Investigates metabolic and physiological response of the body to the diet
  – “From fork to cell”
What is our role in addressing this challenge?

Consumers
• Need better food options
• Need clear messaging on food & health

Industry
• Justification to invest in health
• Strong evidence base to help in communication
• Technological and regulatory roadmap to improving products

Government and Academic Research
• Developing partnerships in Food Science and Nutrition Research
• Generate solid data on food and health including bioactives to inform policy, improve products and develop communication strategies
How do we meet this challenge?

USDA Beltsville Human Nutrition Research Center

North Carolina State University Plants for Human Health Institute

Delivery of Highly Controlled Diets

Clinical Measures & Sample Collection

Food Science

Food Processing

Metabolomics
Implications of Phytochemical-Food Matrix Interactions

Understanding Phytochemicals In Food/Ingredient Systems

Digestive Stability, Bioaccessibility & Bioavailability

Simulated Digestion

Caco-2
Transport

In vivo kinetics

Tissue Deposition

MS Spectra (OMe-EC-b-Glucuronide)

Digestive Stability, Bioaccessibility & Bioavailability

Impact to Bioavailability & Activity

Processing

Macro-nutrients

Micro-nutrients

Phytochemicals

Impact to Bioavailability & Activity

Processing

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MS Spectra (OMe-EC-b-Glucuronide)
Berries and Bone Health: NIH-NCCIH

- Project is exploring the benefits of polyphenol rich blueberries for bone health
- Informing biomedical studies by mapping differences in profiles and delivery of phenolics

Diversity in anthocyanin content in 267 blueberry cultivars from NCSU collection

Mapping content and in vivo bioavailability to identify candidate varieties for biomedical studies

Preclinical

Clinical
Meal lipid profiles and bioavailability of fat soluble carotenoids

- Fat soluble nutrients require fat for intestinal absorption
- What is impact of changes in dietary fat on absorption?

Lycopene

α- & β-carotene

Lutein and zeaxanthin


Impact of Meal Lipid Amount

![Impact of Meal Lipid Amount Graph](image)

Impact of Meal Lipid Type

![Impact of Meal Lipid Type Graph](image)
Meal lipid profiles and bioavailability of fat soluble carotenoids

- Lycopene
- α- & β-carotene
- Lutein and zeaxanthin

Utility of Dietary Reference Intakes
Digestion, Absorption, & Utilization of Dietary Components

Percentage of Americans Not Meeting Recommended Intake

<table>
<thead>
<tr>
<th>Vitamin D</th>
<th>Vitamin E</th>
<th>Magnesium</th>
<th>Calcium</th>
<th>Vitamin A</th>
<th>Vitamin C</th>
<th>Zinc</th>
<th>Vitamin B6</th>
<th>Folate</th>
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</tbody>
</table>

Source: USDA Food Surveys Research Group

Folate
Vitamin B6
Zinc
Vitamin C
Vitamin A
Calcium
Magnesium
Vitamin E
Vitamin D

New Approach: digestibility and available calories from a single food in a mixed diet.

\[ ME = GE_{\text{Food}_1} + GE_{\text{Food}_2} + ... + GE_{\text{Food}_i} \]

- \( GE_{\text{Feces}} = GE_{\text{Food}_1} + GE_{\text{Food}_2} + ... + GE_{\text{Food}_i} \)
- \( GE_{\text{Urine}} = GE_{\text{Food}_1} + GE_{\text{Food}_2} + ... + GE_{\text{Food}_i} \)

Human Feeding Study Results:
- Pistachios - 5% fewer calories
- Almonds - 20% fewer calories
- Walnuts - 21% fewer calories

Baer, Gebauer, Novotny, Br J Nutr 107:120, 2012
Baer, Gebauer, Novotny, J Nutr 146:9, 2016
Gebauer, Novotny, Baer, Food Funct 12:4231, 2016

How much vitamin E do we really need?

Results: Current vitamin E DRI may be higher than actual requirement.

Vitamin E has been accepted for a new DRI review.

Clifford, De Moura, Ho, Chuang, Follett, Fadel, Novotny AJCN 84: 1430, 2006

USDA & University of California, Davis
Supported by USDA ARS, NIH, Almond Board of CA, CA Walnut Commission, and Paramount Farms
The foods we eat interact with the genes we have to affect the diseases we get.

Nutrient-Gene Interactions

Eating garlic → Lower cancer risk

But How?

Garlic altered expression of 7 cancer related genes in humans.

<table>
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<tr>
<th>Gene</th>
<th>Fold-change</th>
<th>P-value</th>
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<tbody>
<tr>
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<td>0.0166</td>
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<tr>
<td>ARNT</td>
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<tr>
<td>HIF1A</td>
<td>1.6</td>
<td>0.0267</td>
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<tr>
<td>JUN</td>
<td>1.7</td>
<td>0.0452</td>
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<tr>
<td>NFAM1</td>
<td>3.0</td>
<td>0.0004</td>
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<tr>
<td>OSM</td>
<td>1.8</td>
<td>0.0005</td>
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<tr>
<td>REL</td>
<td>1.7</td>
<td>0.0158</td>
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P < 0.05

Charron, Dawson, Novotny, J Nutr 146:444S, 2016
Berries Ramp-Up Fat Burning

RESEARCH LETTER

Change in Percentages of Adults With Overweight or Obesity Trying to Lose Weight, 1988-2014
Socially acceptable body weight is increasing. If more individuals who are overweight or obese are satisfied with their weight, fewer might be motivated to lose unhealthy weight. This study assessed the trend in the percentage of adults who were overweight or obese and trying to lose weight during 3 periods from 1988 through 2014.
Snook et al. (2017) JAMA 317:971

 Volunteers burned almost 10 more grams of fat per day when eating blackberries daily

Mice on a high fat diet became obese
Mice on a high fat diet with anthocyanins remained lean

Tsuda et al. 2003

Grams of fat burned daily

Volunteers burned almost 10 more grams of fat per day when eating blackberries daily

USDA ARS & NIFA Funding
USDA, Purdue, NC State University
Body Fatness and Dietary Pattern Affects Absorption & Metabolism of Polyphenols

Daily Intake of Polyphenol-Rich Foods on Controlled Diet

<table>
<thead>
<tr>
<th></th>
<th>Amount (g)</th>
<th>Flavonols (mg)</th>
<th>Flavan-3-ols (mg)</th>
<th>Anthocyanins (mg)</th>
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</thead>
<tbody>
<tr>
<td>Tea</td>
<td>400</td>
<td>-</td>
<td>300</td>
<td>-</td>
</tr>
<tr>
<td>Apple</td>
<td>300</td>
<td>40</td>
<td>26</td>
<td>-</td>
</tr>
<tr>
<td>Blueberry</td>
<td>150</td>
<td>150</td>
<td>-</td>
<td>460</td>
</tr>
<tr>
<td>Total</td>
<td>700</td>
<td>190</td>
<td>326</td>
<td>460</td>
</tr>
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</table>

Different pattern of adaptation for different phytonutrients and for lean vs. overweight individuals.
Take home messages

• Food is the delivery system for nutrition

• Phytochemicals, while not essential, appear to be important for long-term health

• Need more partnerships between food science and nutrition to foster positive changes in dietary guidance and health outcomes

• Strategic funding that can building interdisciplinary teams to address the big issues
Thank You