Greatest Challenges of 21st Century

• Providing a sustainable, safe, and nutritious food supply to meet needs of an expanding world population

• Adapting to and slowing climate change

Triple Burden of Malnutrition

• 805 million undernourished (not enough calories)

• 2,000 million micronutrient deficient (not enough vitamins and minerals)

• 500 million obese (too many calories)


FAO, 2013

FAO

• Economic and human costs of malnutrition are unconscionably high

• Good nutrition begins with food & agriculture


World Population: 1950-2050


http://www.census.gov/population/international/data/worldpop/graph_population.php

Accessed 2/17/2015

Food System Strategies for Preventing Micronutrient Malnutrition

Dennis Miller, PhD
Professor
Department of Food Science
Cornell University

March 19, 2015
**Food System**

“All the people, institutions and processes by which agricultural products are produced, processed and brought to consumers.”

FAO, 2013

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**Strategies for preventing micronutrient malnutrition**

**Strategy 1**

**Produce sufficient food (calories) for all**

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**The Population Bomb**

- Published in 1968
- Best seller
- Warned of mass starvation in 1970’s and 80’s

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**Green Revolution**

- Started in the 1950’s
- High yielding varieties of wheat, rice, and maize
- Improved farming practices
  - Fertilizer
  - Pesticides
  - Irrigation

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**World Cereal* Production–Areas Saved Through Improved Technology, 1950-2000**

- CEREAL PRODUCTION
  - 1950: 650 million tonnes
  - 2000: 1,900 million tonnes

- LAND SPARED
  - 1.1 billion ha

- LAND USED
  - 660 million ha

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*B Uses milled rice equivalents
Source: FAO Production Yearbooks and AGROSTAT

Borlaug, 2005

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**World Food Production**

- Food production
- Population
- Per capita food production

Green Revolution

Unintended Consequences

- Reduced cropping diversity
  - Cereals displaced pulses and other nutrient dense crops
- Reduced availability of micronutrients

Nutrient Concentrations in Rice and Lentils (per 100 g)

<table>
<thead>
<tr>
<th></th>
<th>Brown Rice</th>
<th>Polished Rice</th>
<th>Lentils</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protein (g)</td>
<td>7.5</td>
<td>6.5</td>
<td>24.6</td>
</tr>
<tr>
<td>Iron (mg)</td>
<td>1.8</td>
<td>0.08</td>
<td>6.61</td>
</tr>
<tr>
<td>Zinc (mg)</td>
<td>2.0</td>
<td>1.1</td>
<td>3.3</td>
</tr>
<tr>
<td>Thiamin (mg)</td>
<td>0.41</td>
<td>0.07</td>
<td>0.87</td>
</tr>
<tr>
<td>Folate (µg)</td>
<td>20</td>
<td>6</td>
<td>479</td>
</tr>
<tr>
<td>Vitamin B-12</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>


Strategies for preventing micronutrient malnutrition

Strategy 2

Diversify Diets

MyPlate

- Designed to help consumers make better food choices
- Emphasizes variety

Source: Miller & Welch, Food Policy, 2013
Problems with varied diet recommendations

- Incentives for farmers lacking
- Agricultural research focuses on major crops
- Consumers do not choose varied diet
  - Animal-source foods, fruits, and vegetables are expensive
  - People prefer sweet and high fat foods

Definitions of Food Fortification

The addition of nutrients to foods to achieve a public health objective

Examples

Enrichment of Refined Grain Products in U.S.

Nutrient Deficiency Diseases

- Signs and symptoms may develop in a few months
- Not contagious
- Caused by a lack of one or more nutrients
- Reversible if nutrient is restored in time
  - May not be as reversible as previously thought

Mass Fortification

Foods consumed by general population
Folic Acid Fortification in U.S. began in 1996

- Prevalence of low serum folate decreased from 21% to < 1%
- Prevalence of NTDs decreased by 36%

CDC. 2010. http://www.cdc.gov/mmwr/preview/mmwrhtml/mm5931a2.htm

Fortified foods are major contributors to nutrient intakes in diets of US children and adolescents

ILSI North America Fortification Committee Discussion Meeting, January 22, 2013

Louise Berner, PhD
California Polytechnic State University
San Luis Obispo

Impact of Added Nutrients and Supplements in Females 14-18

Impact of Added Nutrients and Supplements in Females 14-18

Berner et al. 2014

Iodine Deficiency

- Consequences
  - Goiter
  - Cretinism
  - Impaired mental and physical development
  - Poor pregnancy outcomes
  - Increased infant mortality

Example

Global Universal Salt Iodization Program

Iodine Deficiency

- 1990: UN World Summit for Children set goal to eliminate iodine deficiency
- Universal Salt Iodization Programs (USI) established in many countries
- Household access to iodized salt
  - 1990: < 10%
  - 2013: > 90%

Elizabeth N. Pearce, Maria Andersson, and Michael B. Zimmermann. Thyroid. May 2013, 23(5): 523-528.

Benefits and Limitations of Food Fortification

Benefits of Fortification

- Fortified foods deliver a consistent, regular amount of nutrients
- Fortified foods can deliver multiple nutrients
- Fortified foods can be tailored to meet the needs of populations


Benefits of Fortification

- Fortified foods have potential to reach everyone in a population, rich and poor alike


Benefits of Fortification

- Does not require changes in existing food patterns
- Does not require compliance by individuals


Benefits of Fortification

- Often more cost effective than other strategies for reaching large numbers of people

Limitations of Fortification

- The fortified food may not be consumed by everyone
- Fortified foods will be consumed by many who do not need the extra nutrients


Limitations of Fortification

- Potential harm to non-target people
  - Folic acid may mask symptoms of B-12 deficiency in elderly
  - Excess folic acid may promote growth of pre-neoplastic lesions

Limitations of Fortification

- Fortified food may not reach the people who need them the most
  - Poorest of the poor
  - People consuming “own grown” food


Limitations of Fortification

- Cost
  - Nutrients are inexpensive by our standards but not by everyone’s
  - Requires specialized processing equipment and trained workers
  - Requires government surveillance system
  - May require educational programs


Biofortification

- Increasing the concentration and/or bioavailability of nutrients in foods through genetic selection or manipulation
  - Conventional plant breeding
  - Genetic engineering (e.g. golden rice)
HarvestPlus

• Global alliance of institutions and scientists
• Coordinated by
  – International Center for Tropical Agriculture (CIAT)
  – International Food Policy Research Institute (IFPRI)
• Directed by Howarth Bouis

http://www.harvestplus.org/about.html

HarvestPlus

• “HarvestPlus seeks to reduce micronutrient malnutrition among the poor by breeding staple food crops that are rich in micronutrients through a process called biofortification.”

http://www.harvestplus.org/about.html

HarvestPlus

• Target Nutrients
  ▪ Vitamin A
  ▪ Iron
  ▪ Zinc

• Target Crops
  ▪ Beans
  ▪ Cassava
  ▪ Maize
  ▪ Pearl Millet
  ▪ Rice
  ▪ Sweet Potato
  ▪ Wheat

http://www.harvestplus.org/about.html

HarvestPlus

Advantages of a Biofortification Strategy

• One time cost to develop biofortified seeds
• Biofortified foods can reach the poor in remote areas

http://www.harvestplus.org/about.html

Effect of an intervention to introduce OSP in rural Uganda on the prevalence of inadequate vitamin A intakes among children and women.

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Strategies for preventing micronutrient malnutrition

Strategy 5

Reduce food losses and food waste
Food Losses and Waste

- Between 30 and 50% of food produced is wasted
- Developing countries:
  - Most food is lost before it reaches the consumer
    - Insects/rodents
    - Spoilage (bacteria, enzymes)
    - Limited access to markets
- Developed Countries:
  - Most food waste is post-consumer
    - Past sell-by date
    - Blemishes
    - People purchase more than they need
    - Serving sizes are too large

Strategies for reducing food waste

- Developing countries
  - Develop infrastructure (e.g. roads, railroads, cold chains)
  - Introduce food processing technologies (drying, canning, freezing)
  - Develop markets for raw and processed foods
- Developed countries
  - Reduce serving sizes
  - Educate consumers on proper storage and handling of foods
  - Reevaluate "best if used by" labeling

Key Message

Expand commercial fortification programs

Key Message

Develop and implement technologies to biofortify foods

Key Message

Reduce food losses and food waste

Key Message

Build human capacity in agriculture, food processing, and nutrition
Key Message

Adopt a holistic systems approach to the problem

“It is no longer acceptable to delay the use of any strategy that is safe and will help us achieve the ability to feed the world’s people.”

Raven, Transgenic Research, 2013

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Thank you!