Animal-source foods for nutrition, health, and welfare of infants, children, and pregnant/lactating women

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University of Florida Presentation
Chapter of Sigma Xi, The Scientific Research Society, the College of Public Health, the Department of Animal Sciences, and the Feed the Future Innovation Lab for Livestock Systems
1) Nutrition rationale for animal source foods
   • ASF matrix: bioavailability of critical nutrients
   • Evolutionary basis for ASF

2) Research
   • Egg nutrition among indigenous groups – Ecuador
   • Milk nutrition among pastoralists – Kenya

3) Conclusions
   • Research Agenda
   • Policy & Programming Agenda
Impact of undernutrition

45% child deaths due to undernutrition

WHO 2011, Black et al. 2013
Undernutrition in first 1,000 days...

- **Undernutrition** in young children < 5 yrs
  - 164.8 million stunted (25.7%)
  - 100.7 million underweight (15.7%)
  - 51.5 million wasted (8%)

- **Hidden hunger** – micronutrient deficiencies
  - 33% children vitamin A deficient
  - 18% children anemic (some iron deficiency)
  - 17.3% world zinc deficient; 28% world iodine deficient

Stunting
Severe wasting
IUGR
Sub-optimal breastfeeding
Vitamin A deficiencies
Zinc deficiencies

3.1 million (45%) of deaths to children <5 yr (2013)

140.5 million (35%) of DALYs for children < 5 yr and 10% of global DALYs (2008)
… the next 3,000 days

- **Brain development** – prefrontal cortex for higher cognitive functions; synaptogenesis and pruning; and neurogenesis in hippocampus (Grantham-McGregor et al. 2007)

- **Micronutrient deficiencies** - 20-30% of school-aged children have deficiencies in iron, iodine, zinc, and vitamin A (Best et al. 2011)
  - Haiti: 73% were anemic; 14% were stunted; 9.1% thin; and low % fat mass boys (8%) and girls (12.5%)

- **School feeding programs** - largest investments in public food programs globally (Lentz & Barrett 2013)
  - Potential for local agriculture development & nutrition impacts (Iannotti et al. 2013)
Human brain development
(Grantham-McGregor et al. Lancet 2007)

Figure 1: Human brain development
Essential Nutrients

• Constituents in the diet required for growth, health, and survival, not sufficiently produced endogenously.

  – Macronutrients – protein/amino acids, carbohydrates, lipids/fatty acids, fiber

  – Micronutrients
    • Vitamins (organic) – A (β-carotene, retinol), B (thiamin), riboflavin, niacin, pyridoxine, cobalamin, pantothenic acid, folate), C (ascorbic acid), D (calciferol), E (α-tocopherol), K, choline

    • Minerals/elements/trace minerals (inorganic) – calcium, iron, zinc, iodine, selenium, copper, fluoride, phosphorus, magnesium, manganese

  – Water & electrolytes – sodium, chloride, potassium, inorganic sulfate
Single nutrient versus food matrix

Historical origins
• Nutrient discoveries in relation to disease – scurvy (vit C, 1753), beri beri (thiamine), rickets (vit D), goiter (iodine)
• Technologies that enable supplementation, fortification and biofortification

Global nutrition programming and policy
• Vitamin A supplementation
• Fortification (iodized salt, folic acid in wheat) and biofortification (golden rice, orange flesh sweet potatoes)

What is the harm?
* Potential for overload
* Physiology not constituted for single nutrients
Food matrices: it’s all in the packaging

Limiting nutrient  | ASF matrix | ASF: plant form absorption rate
--- | --- | ---
Vit A → | ![Vitamin A molecule](image) | 12-24x (ug)
Iron → | ![Iron absorption image](image) | 2x (mg)
Zinc → | ![Zinc absorption image](image) | 2x (mg)
Choline → | ![Choline molecule](image) |
Leveraging Nature’s Technology: eggs & milk

Over thousands of years…

1) nature perfected the nutritional composition

2) crafted to sustain early life, completely

3) economically affordable and environmentally sustainable
Eggs: provides >50% of nutrients (++) and 20-50% (+) for breastfed infants 7-12 mo
Importance of ASF

EVOLUTIONARY RATIONALE
Evolutionary basis: anthropology of anthropometry

- **Homo erectus (2.6 mya)**
  - Differed from Australopithecus garhi & Homo habilis
  - Bigger brain & body
  - Smaller intestine & teeth

- **Agriculture (10,000 ya)**
  - Mobility no longer necessary
  - Homo sapiens shorter
Evidence-based Paleo Diet

• Discordance theory (Konner & Eaton 1985)
  – Human genome evolve to adapt to conditions that no longer exist. Mismatch is causing chronic diseases

• Plant-animal ratios (Cordain et al. 2000)
  – Ethnographic evidence from 229 hunter-gatherer societies
  – Proportion of energy intakes: animal foods (45-65%)

• “Meat made us human” (Bunn 2007)
  – Plio-Pleistocene Era East African Rift Valley - Mary Leakey discoveries
  – In-tact carcasses & flaked stone tools

(Cordain et al. AJCN 2000)
Paleolithic vs. modern time macronutrient ratios

- **Cordain**: 34% Carbohydrate, 36% Fat, 30% Protein
- **United States**: 52% Carbohydrate, 33% Fat, 15% Protein
- **Highest Income Quartile, Developing Countries**: 68% Carbohydrate, 20% Fat, 12% Protein
- **Lowest Income Quartile, Developing Countries**: 76% Carbohydrate, 13% Fat, 11% Protein
Paleolithic nutrition: key differences

- **Energy ↑** - due to physical demands
- **Carbohydrates** (45-50%, similar) – different types, many varieties of fruit & vegetables, rarely grains, and no refined sugar
- **Protein ↑** (30% of energy) - marine (ocean), lacustrine (lake), and riverine (river) species, meat
- **Fatty acids** – different types lean game meat, fish/shell foods, n-6:n-3=1; DHA↑
- **Micronutrients ↑** – many varieties and high levels of fruits, nuts, legumes exceed today’s DRIs
- **Potassium (K⁺):Sodium (Na⁺)** >5 in HG; (alkaline in HG rather than acidic) now Na⁺ > K⁺
- **Fiber ↑** - (>100 g/d compared to 20 g/d) - other phytochemicals, flavonoids, plant phenols
Meat on Mondays: ag-nutrition strategy

- *Meatless Mondays* Campaign dating back to WWI
  - rationing strategy

- Center for Livable Future at JHSPH revived in 2003
  - environment strategy

- Change to *Meat on Mondays*
  - ag-nutrition strategy
Global distribution of eggs, milk, & fish availability
(FAO data 2011)
Affordable & nutrient-rich foods....

http://livingwithgastroparesis.com/weekly-round-up-eggs/
https://www.msc.org/cook-enjoy/fish-to-eat/sardine
...through systems-level changes
Egg nutrition – Pastocalle, Ecuador
Lulun Egg Project

- RCT to test effects of daily egg consumption among children 6-9 mo for six months (n=163)
- Eggs purchased from small-medium size producers
- Outcomes: anthropometry, biomarkers of choline, vitamin B$_{12}$, lipids and amino acids
Social Marketing

- Intent: motivate participation, communicate RCT and study rationale

- Activities
  - Entertainment
  - Messaging - logo
  - Workshops (egg recipes, flower arranging)

- Successes
  - Despite Cotopaxi volcano
  - 8% losses-to-follow-up
GLM models for growth effect

<table>
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<tr>
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<th>Effect size or PR</th>
<th>95% CI</th>
<th>p value</th>
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<td>0.609</td>
<td>(0.36-0.86)</td>
<td>0.000</td>
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<tr>
<td>Weight-for-age Z</td>
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<td>(0.45-0.77)</td>
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<td>Weight-for-length Z</td>
<td>0.346</td>
<td>(0.16-0.53)</td>
<td>0.000</td>
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<tr>
<td>BMI Z</td>
<td>0.302</td>
<td>(0.09-0.51)</td>
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<td>Stunted</td>
<td>0.540</td>
<td>(0.37-0.78)</td>
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<tr>
<td>Underweight</td>
<td>0.296</td>
<td>(0.12-0.72)</td>
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</table>

Adjusted for child age, sex, and baseline anthropometry
Growth effects – Kernel density estimate

**a. Control group**

**b. Egg group**
Related research

- Small livestock development and the value chain
- Social marketing for research design innovations
- Spatial and altitude determinants of nutrition in indigenous communities of Ecuador
Pastoralist milk nutrition: Samburu, Kenya

• Livelihood transition:
  – ↓ Land access (adjudication frequent droughts)
  – ↑ Sendentarization (policies, mandatory education, poverty)

• 2 comparable communities
  – Siambu: livestock
  – Mbaringon: cultivation

• Longitudinal data
Pathways to nutrition impacts

Figure 9: Causal Pathways

- Intervention (improved goats+BCC)
- ↑milk production
- ↑milk availability
- ↑HH income and assets
- ↑knowledge nutrition & health
- ↑HH milk consumption
- Improved child diet and feeding practices
- Increased access and use of health behaviors, services & products
- Women’s access to assets and role in decision making increases
- ↑child growth (HAZ)
- Improved child health
- Improved household well-being
- Women’s status improved
High levels of nutrient inadequacy

Iannotti and Lesorogol CA 2014
Maize dependency - % daily kcals

- Maize: 52%
- Milk: 10%
- Sugar: 11%
- Fat: 10%
- Beans: 10%
- Potatoes: 2%
- Rice: 4%
- Meat: 1%
- Vegetables: 0%
### Table 3. Food group source of nutrients (%), 2010

<table>
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<tr>
<th></th>
<th>Energy</th>
<th>Vitamin A</th>
<th>Vitamin B&lt;sub&gt;12&lt;/sub&gt;</th>
<th>Vitamin C</th>
<th>Folate</th>
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<td>Rice</td>
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<td>0</td>
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<td>13</td>
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<td>Potatoes</td>
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<td>0</td>
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<td>2</td>
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<td>Beans</td>
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<td>0</td>
<td>0</td>
<td>57</td>
<td>27</td>
<td>21</td>
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<tr>
<td>Meat</td>
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<td>0</td>
<td>0</td>
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<td>3</td>
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<td>94</td>
<td>50</td>
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<td>Vegetables</td>
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<td>Sugar</td>
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Iannotti and Lesorogol CA 2014
Livestock ownership improves nutrient intake

**Findings:**
- Livestock ownership increased nutrient adequacy for vitamin A, B₁₂, and zinc (adj $R^2=.06-.16$; $P<.001$) (Iannotti and Lesorogol CA 2014)
- Milk consumption increased BMI $z$ scores among youth ($P<0.001$) (Iannotti and Lesorogol AJPA 2014)
- Cattle and chicken ownership increased dietary diversity (adj $R^2=.33$; $P<.001$)

**Conclusion:**
- Support livestock development among pastoralist households for child milk consumption and nutrition

**Next steps:**
- Intervention study to examine improved breeds and managements of goats on: milk production and poverty reduction; milk consumption, nutrition, and health; and gender empowerment.
CONCLUSIONS

Research, Policy, and Programming Agenda

CONCLUSIONS
Opportunities: the ASF potential

1) Food matrix: ASF nutrient matrices facilitate absorption of critical nutrients including vitamins A, B12, choline, iron, and zinc

2) Evolutionary basis: “periodic” ASF consumption

3) Sustainable development: small livestock production can contribute to sustainable development
Research Agenda

• Production pathways to nutrition
  – Household ASF availability → vulnerable group consumption
  – Household wealth → high quality foods & health behaviors

• One Health
  – Livestock management/BCC for poultry and human health
  – Reduce infectious disease exposures (respiratory + enteric disease)

• Improve research design for ag-nutrition
  – RCT, cluster, quasi-experimental designs
  – Mixed methods – qualitative, quantitative, GIS, etc.
  – Transdisciplinary – public health, nutrition, agronomy, economics, anthropology, environment
Research Agenda cont.

• What is the minimum ASF needed to sustain nutrition in vulnerable populations without crossing the threshold for increased chronic disease risk?
  – Can we responsibly promote ASF in vulnerable populations to achieve more equitable distribution in world markets?

• What potential lies in small livestock development to improve nutrition through synergistic impacts on poverty, availability/access to high quality foods, and women’s empowerment?
  – School-based ASF interventions that support local economic development.
  – Household level ASF interventions targeting young children

• Will poor households reserve eggs and milk for vulnerable groups, while selling others for livelihood?
  – What health and nutrition messages are needed?
Policy & Program Agenda

Policy
• Environment rationale – small livestock-ag development
• Macro-economic policies
  – Trade policies to move toward more equitable distribution of affordable ASF
  – Pricing and subsidy programs that might improve access to ASF
• Affordable ASF more explicitly into CF guidelines

Programming
• Nutrition-specific prevention strategies that ensure adequate dietary intake of ASF
  – 1,000 days (IYCF, maternal nutrition)
  – 3,000 days (health and development)
• Nutrition-sensitive – transdisciplinary
• Evaluation!
Thank you