Understanding food systems-diet quality-nutritional outcome linkages with nuclear techniques

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75th Anniversary of the International Union of Nutrition Sciences (IUNS)
IAEA Mandate

“Atoms for Peace and Development”
To seek to accelerate and enlarge the contribution of nuclear techniques to peace, health and prosperity throughout the world.
Nutrition for Improved Human Health
Using stable isotopes to combat malnutrition throughout life

- Early Life Nutrition
- Prevention and Management of NCDs
- Diet Quality and Nutrition Security
## Support Mechanisms of IAEA

### Coordinated Research Projects
- Call for research proposals
- Respond to research questions
- Small group of research institutes
- 4-5 year cycles
- Small annual grants
- Regular coordination meetings

### Technical Cooperation Programme
- Concept submission from Member States
- Building and strengthening capacity to use stable isotope techniques
- Biannual planning cycle
- Training, expert advice, equipment, sample analysis, data management/analysis
CRPs and TC projects in 2020

- **CRP projects**

- **TC Projects**
  - Last Update: 2020-07-10 10:14:25

- **Pie Chart**
  - 1. Early Life Nutrition: 43.3%
  - 2. Prevention and Management of: 33.3%
  - 3. Diet Quality and Nutrition Security: 23.3%
Example: climate change vs food quality

Percent reduction in nutrient availability due to climate change by 2050

How stable isotope help in dynamic food systems
IAEA’s Support of Nuclear Applications in Nutrition

- Protein quality
- Micronutrient bioavailability
- Vitamin A body stores
- Environmental enteric dysfunction
- Breastfeeding practices
- Body composition
- Total energy expenditure
- Bone density

Stable isotopes

+ Zinc
+ Iron
+ Vit A
Breast milk intake in first 12 months

By infant’s age

By breastfeeding mode

![Bar chart showing breast milk intake by age](image)

- 1.5 mo (n=86): 705 g/d
- 3 mo (n=258): 747 g/d
- 6 mo (n=185): 751 g/d
- 9 mo (n=133): 679 g/d
- 12 mo (n=131): 729 g/d

![Bar chart showing breast milk intake by breastfeeding mode](image)

- Exclusive (n=146): 844 g/d
- Predominant (n=21): 654 g/d
- Partial (n=71): 503 g/d

Reported breastfeeding category
Greater household food insecurity is associated with lower breast milk intake among infants in western Kenya

- 119 mother-infant dyads recruited in western Kenya
- Food insecurity assessed using a validated 9-item household food access scale
- Breast milk intake measured using the deuterium oxide dose-to-the-mother technique

- As food insecurity increases, breast milk intake decreases
- Biologically significant: a 20-point increase in food insecurity would be associated with infants consuming 79.0 kcal less from breast milk
- Screening for and integrating programs that reduce food insecurity may increase quantities of breast milk ingested
Micronutrient deficiencies have short-term and long-lasting impact across the lifespan

Micronutrients of public health significance (Iron, Vitamin A, Iodine, Folate, Zinc)

- Iron deficiency affects 2 billion people globally
- 1 in 5 maternal deaths due to anemia
- 17.3% of global population is zinc deficient; pregnant women and young children are greatest risk
- 250-500 million children are blind because of VAD
- 10-20% of pregnant women in LMIC are suffer from VAD
1. Dose of vitamin A labelled with stable isotope administered after baseline blood sample
2. Dose mixing with vitamin A body pool, then follow-up blood sample taken
3. Sample analysis by mass spectrometry; data used in prediction equations, along with key assumptions about absorption, storage, and catabolism of dose, to estimate total body retinol stores
Fortified extruded rice improved vitamin A status of school children in Thailand

Children’s vitamin A reserves doubled, with no change in serum concentrations

<table>
<thead>
<tr>
<th></th>
<th>Intervention</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Serum retinol, µmol/L</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Baseline</strong></td>
<td>1.21 ± 0.19</td>
<td>1.18 ± 0.26</td>
</tr>
<tr>
<td><strong>Endline</strong></td>
<td>1.28 ± 0.27</td>
<td>1.15 ± 0.23</td>
</tr>
<tr>
<td><strong>Total body reserves of VA, µmol retinol</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Baseline</strong></td>
<td>153 ± 66</td>
<td>108 ± 67</td>
</tr>
<tr>
<td><strong>Endline</strong></td>
<td>269 ± 148*,**</td>
<td>124 ± 89</td>
</tr>
</tbody>
</table>

*Different from control group, p<0.05, **Different from baseline, p<0.05

PINKAEW S et al, J Nutr 144 (2014) 519-524
Food-based strategies to improve vitamin A intake – bioeffciacy of Moringa oleifera and Kale

✓ High vitamin A value
✓ **Moringa leaves** (Mexico)
  Bioconversion factor of 1.47:1 by weight when prepared as puree
✓ **Kale** (Zimbabwe)
  Bioconversion factor of 13.4:1 or 11.0:1 by weight when pureed and prepared with peanut butter or lard
✓ Important source of vitamin A in preschool children

LOPEZ-TEROS V et al, J Nutr 147 (2017) 2356-63
MUZHINGI T et al, Asia Pac J Clin Nutr 26 (2017) 1039-1047
1. Fe stable isotopes added to test meals after taking 1st blood sample

2. Retention of isotopes after 2 weeks determined in blood (2nd blood sample); 80% of absorbed iron incorporated into RBCs

3. Iron is analyzed by mass spectrometry; ratios of stable isotopes compared before and after dosing to determine amount of iron incorporated into the RBCs
India: Zinc and iron in biofortified pearl millet bioavailable

- Quantities of iron and zinc absorbed greater than from non-biofortified grain
- Meet physiological requirements of young children if eaten as the major food staple

KODKANY BS et al, J Nutr 13 (2013) 1489-1493
Example from Botswana

Assessment of iron bioavailability from a sorghum-soya supplementary food: Tsabana fortified with different iron compounds in children aged 12-36 months in Botswana using stable isotopes

TSABANA as a complementary food

- The Botswana Ministry of Health & Wellness provides Tsabana as a fortified weaning food to infants to alleviate infant nutritional deficiencies.

- Tsabana is made up of a mixture of precooked sorghum soya bean meal and fortified with either ferrous fumarate or ferrous sulphate at the discretion of the producer.

Courtesy: Dr Boitumelo Motswagagole
Example from Benin

Project BEN6009: Evaluating the Nutritional Status of Schoolchildren and the Bioavailability of Iron in Meals Served in School Canteens (BENIN)

TC BEN 6009: Implemented to date

- Inventory of the meals served in school cantines in Benin ~ 20 meals are found in the school cantines
- Identification of two recipes iron rich: *Djongoli* and *Atassi*: foods made from locals ingredients
- Lab analysis: Iron contents of *Djongoli* and *Atassi* recipes were 4.6±2.5mg and 1.57±0.57mg/100g, respectively
- Improvement of iron bioavailability of *Djongoli* and *Atassi*: Add baobab juice to both meals; design of the study ongoing
  - Baobab: easily and locally available and very affordable, a local food more twice rich in vit C than orange

Courtesy: Prof Waliou A. Hounkpatin
Example from Benin

Two potential iron-rich meals selected in school canteen

- Djongoli
  - Beans + Maize flour

- Atassi
  - Beans + Rice

Better iron availability in the both school lunch meals?

Add baobab juice

Courtesy: Prof Waliou A. Hounkpatin
Protein quality

- Protein quality is the ability of a food to provide an adequate amount and balance of essential amino acids.

- Protein quality is important for body structure, growth, regulation of organs and tissue function, protection against infection.

- Protein inadequacy and quality significantly related to stunting in children.

- Most plant-based diets deficient in essential amino acids such as lysine and methionine.

- Protein deficiency in infants and young children: mortality, stunted growth, low work output, premature aging and reduced lifespan.
Protein Digestion from Plant-based diets

A new dual isotope tracer technique allowing for true protein digestion assessment as recommended by FAO.
Protein-quality evaluation of complementary foods in Indian children


Published: 28 March 2019 Article history

Pinto Bean Amino Acid Digestibility and Score in a Mexican Dish with Corn Tortilla and Guacamole, Evaluated in Adults Using a Dual-Tracer Isotopic Method

Ana M Calderón de la Barca, Gerardo Martínez-Díaz, Érika N Ibarra-Pastrana, Sara Devi, Anura V Kurpad, Mauro E Valencia

Investigation of different time points of anthesis for intrinsically isotopic deuterium labelling on the enrichment of deuterium-labelled indispensable amino acids in mung bean (Vigna radiata L. Wilczek)
Challenges/Limitations

- Stable isotopes for assessing diet quality are expensive
- Expensive and complex instrumentation not always compatible with LMIC settings
- Small sample sizes due to cost
- Need for highly skilled laboratory personnel
- All the above limit scalability and coverage
- Acceptability and ethical issues since techniques involve blood draws
Opportunities

Stable isotope techniques: accurate, non-invasive

Assessment of efficacy/effectiveness/impact:
- Bioavailability/absorption of iron and zinc from biofortified food varieties
- Vitamin A bioefficacy of crops
- Protein quality from diets
- Impact of food-based interventions on vitamin A status

Scale up and further research through IAEA’s Technical Cooperation Programme and Coordinated Research projects

Contribution to international databases; e.g. FAO database on true ileal protein digestibility

Contribution to future efforts on protein intake and revisiting protein requirements, especially for young children

Development of hand-held instruments and breath assays

Further simplification of the isotope techniques
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