IAEA
International Atomic Energy Agency

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

17 November 2021

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

IUNS
INTERNATIONAL UNION OF NUTRITIONAL SCIENCES

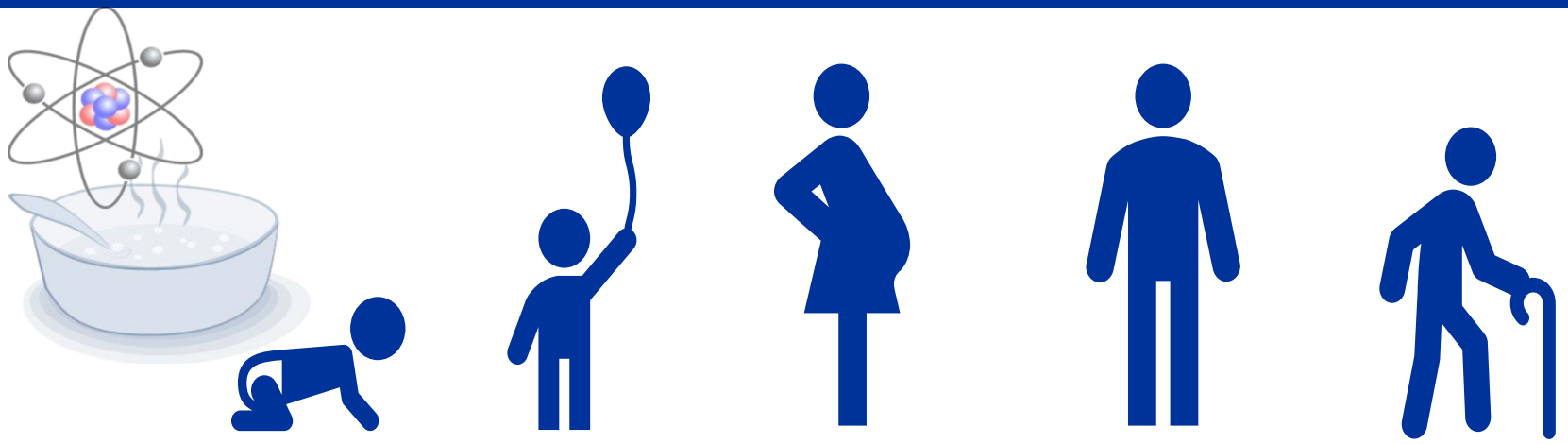
IAEA Mandate

“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

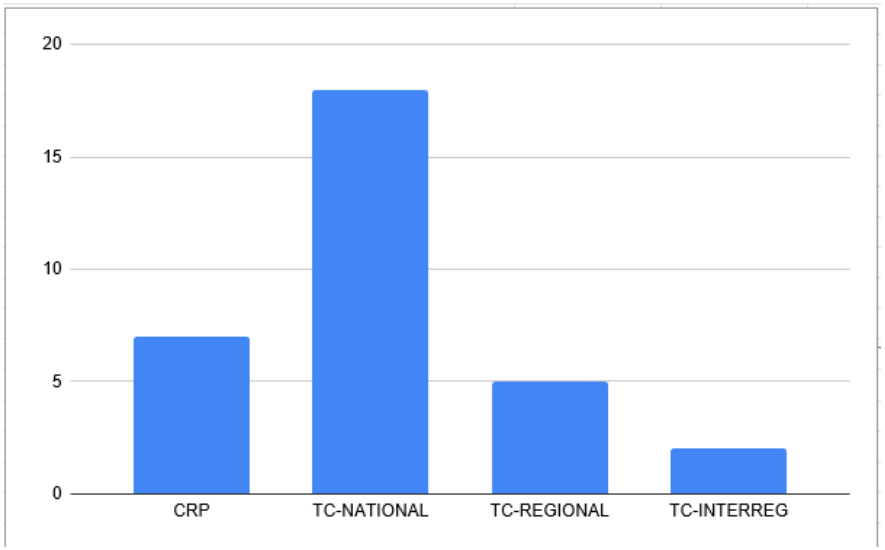
Coordinated Research Projects

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

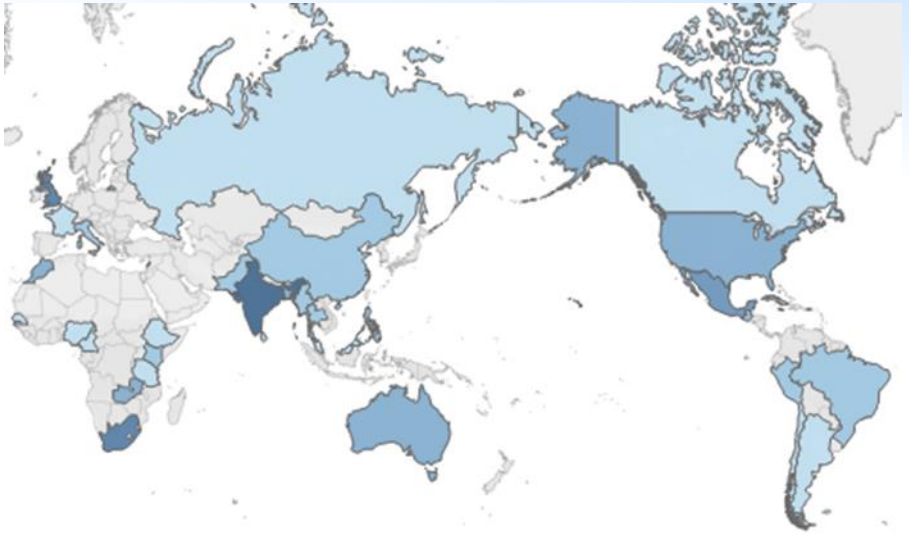
Technical Cooperation Programme

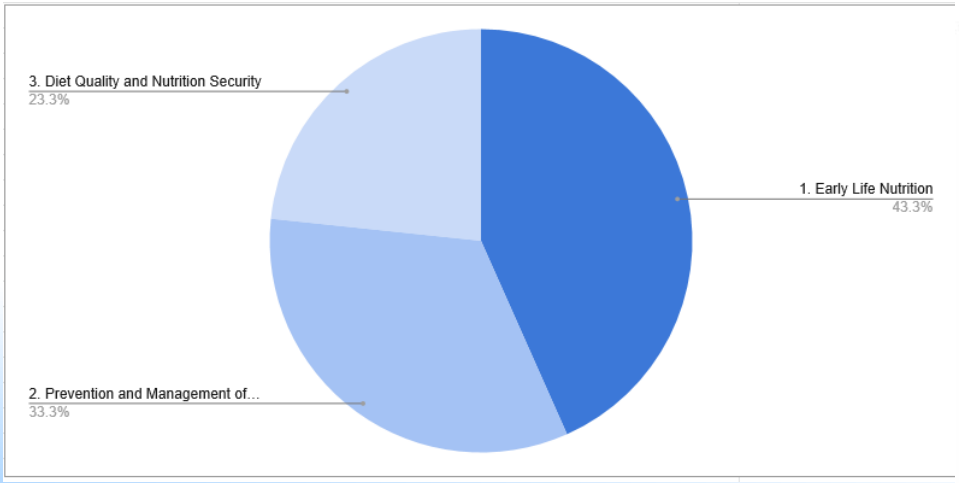
- Concept submission from Member States
- Building and strengthening capacity to use stable isotope techniques
- Biannual planning cycle
- Training, expert advice, equipment, sample analysis, data management/analysis

CRPs and TC projects in 2020



CRP projects

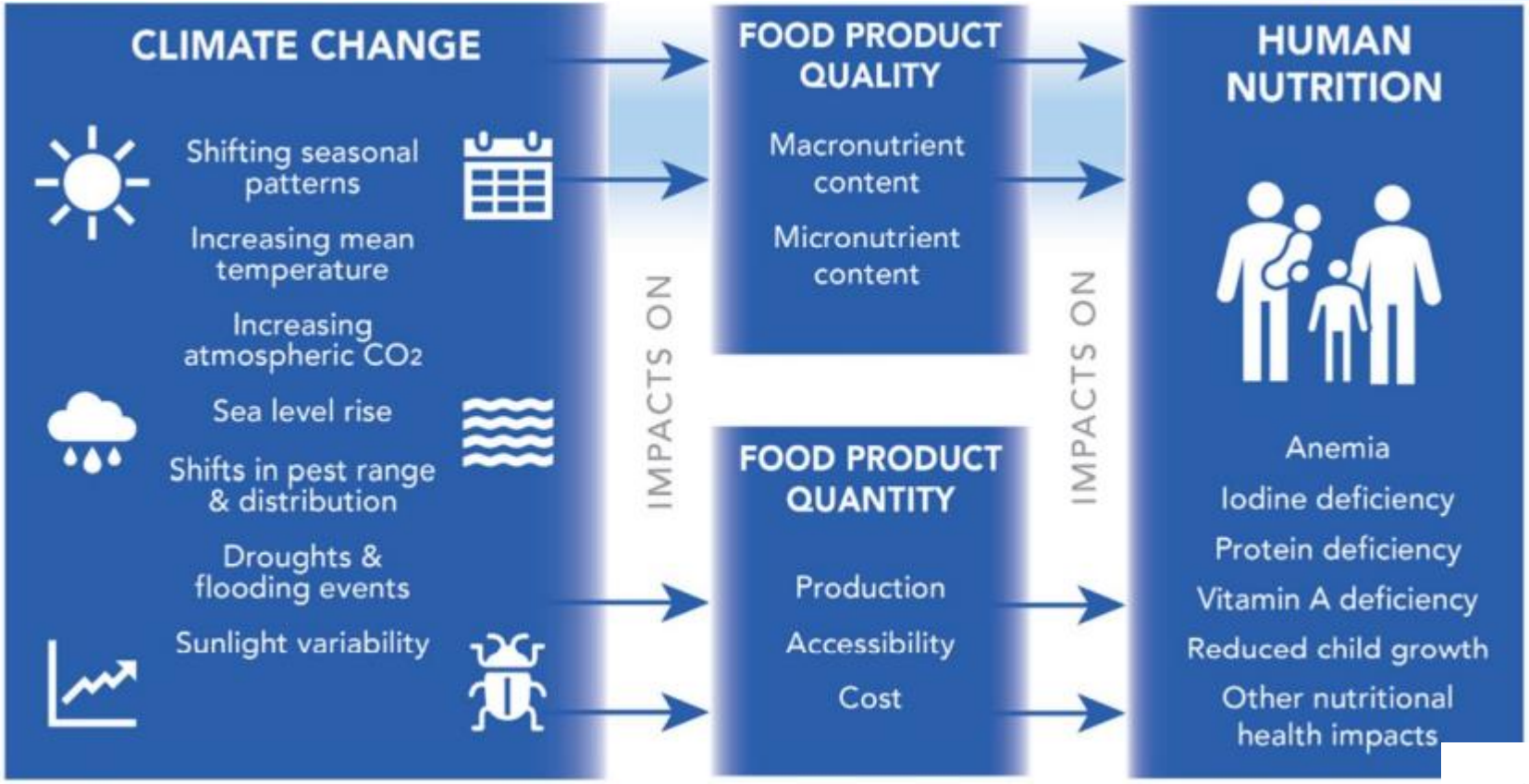




TC Projects

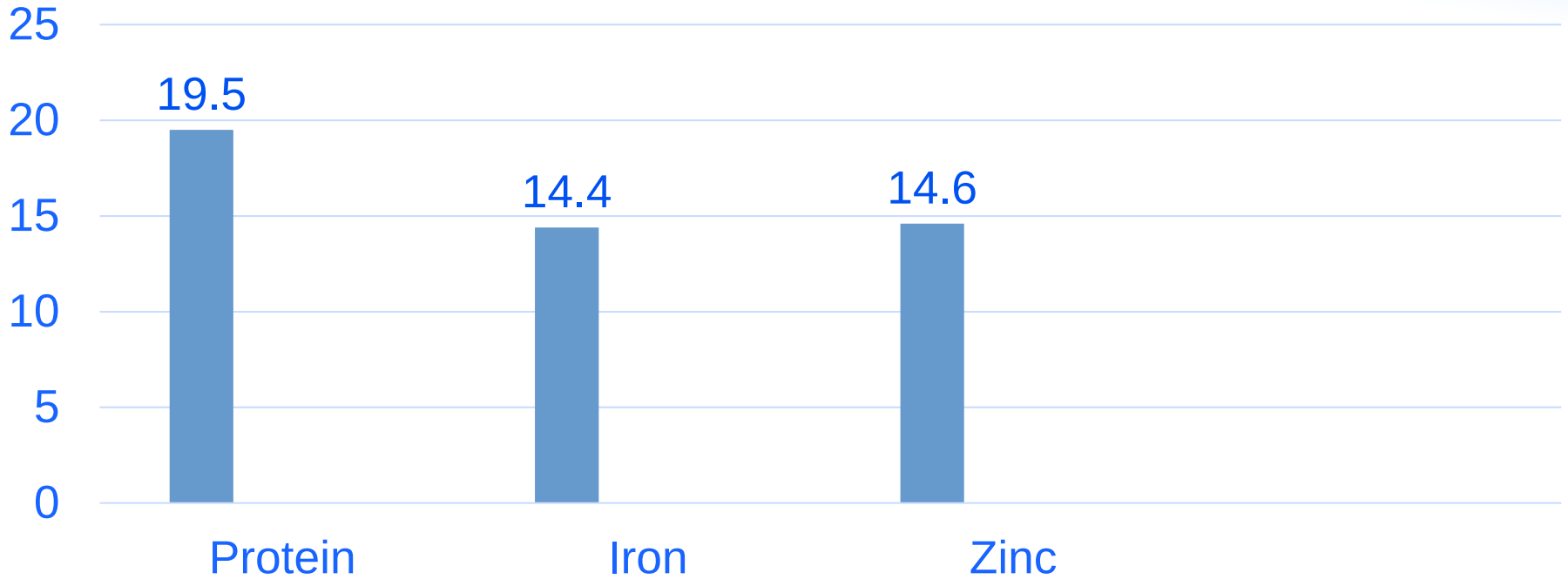
Last Update: 2020-07-10 10:14:25

Example: climate change vs food quality



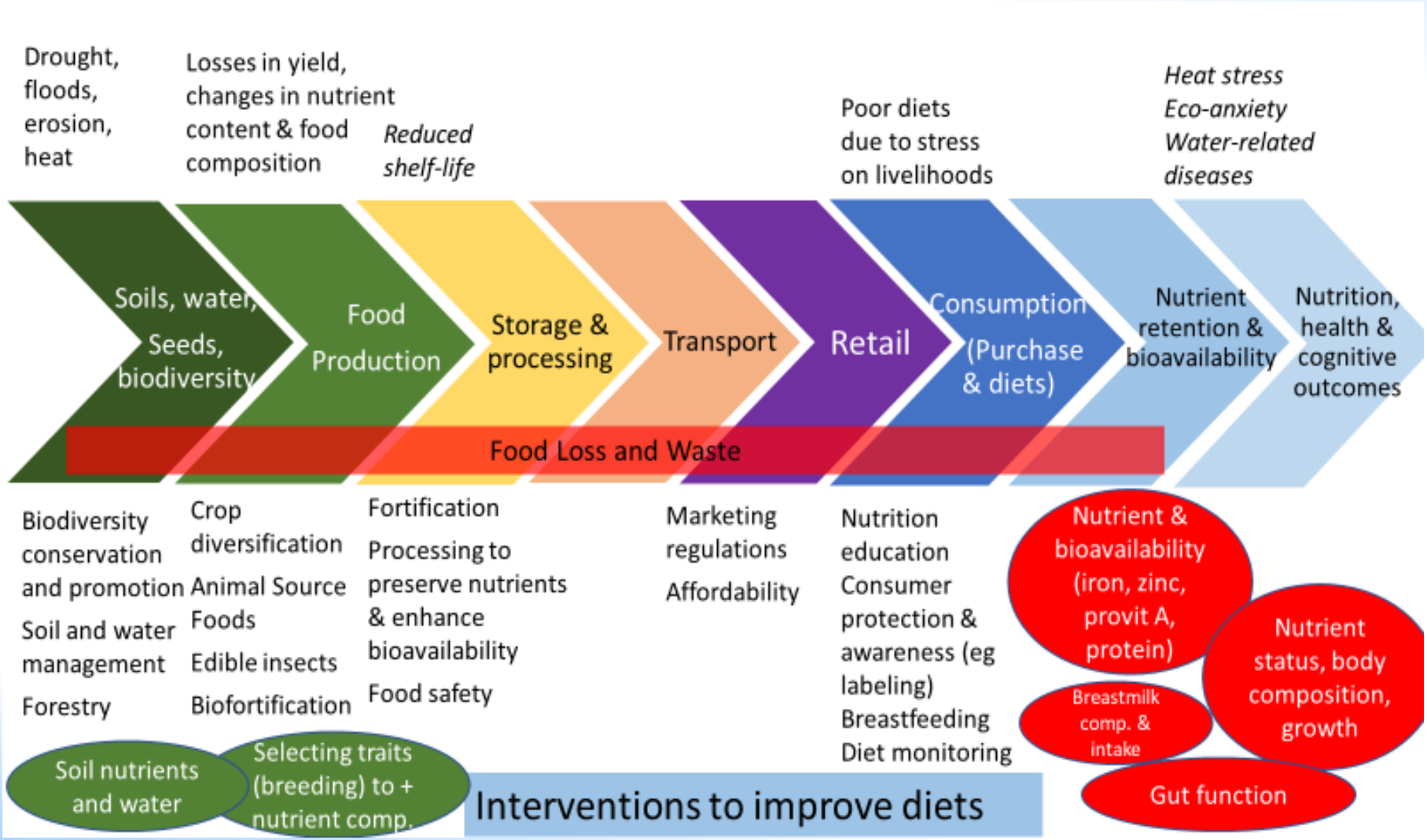
Giulia et al. Environ. Res. Lett. 15 (2020) 113002

Percent reduction in nutrient availability due to climate change by 2050

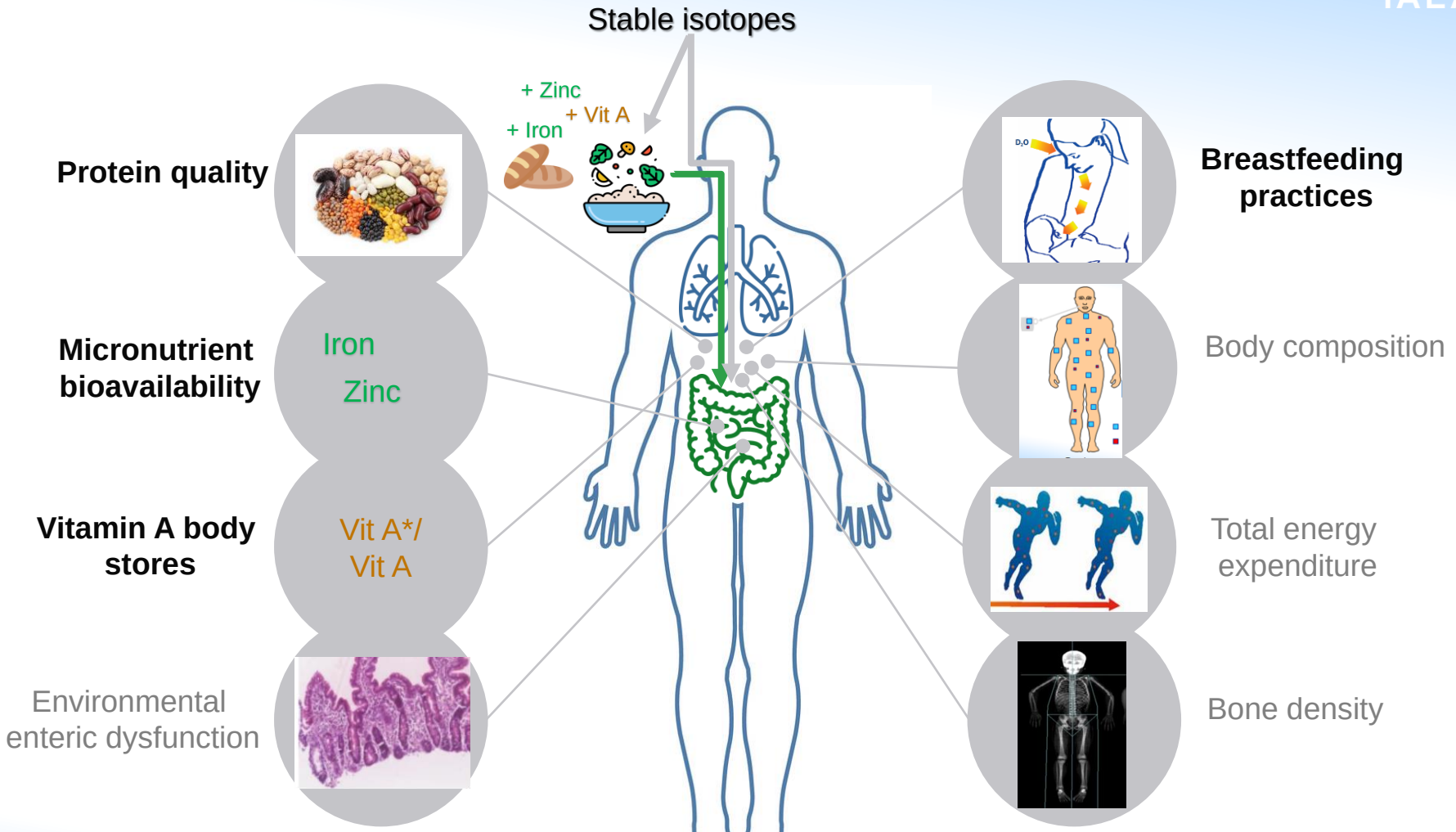


Beach et al., *The Lancet Planetary Health*, 2019; 3 (7): e307.

How stable isotope help in dynamic food systems

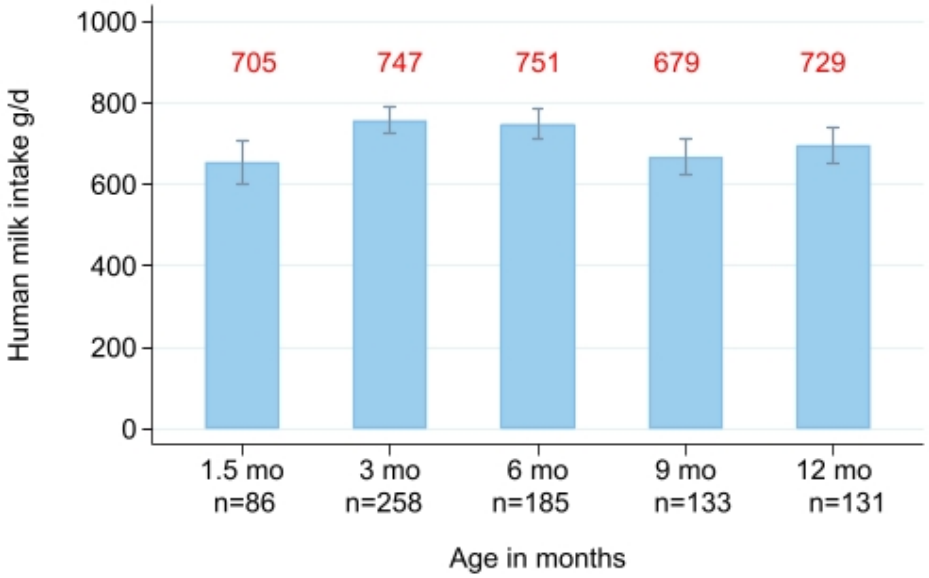


IAEA's Support of Nuclear Applications in Nutrition

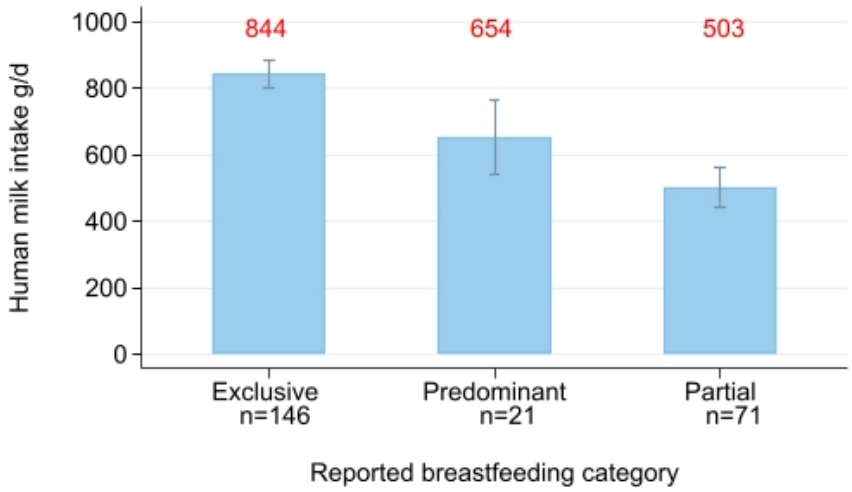


Breast milk intake in first 12 months

By infant's age



By breastfeeding mode



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

Maternal & Child Nutrition

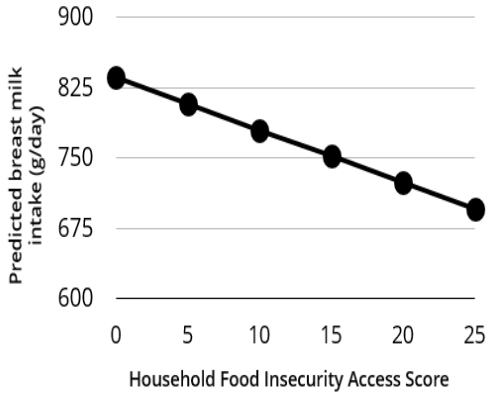
Matern Child Nutr. 2019 Oct; 15(4): e12862.
Published online 2019 Jul 29. doi: 10.1111/mcn.12862
PMCID: PMC6800760
NIHMSID: NIHMS1037530
PMID: 31222968

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

Joshua D. Miller,[1] Sera L. Young,[1] Godfred O. Boateng,[2] Shadrack Oiye,[3] and Victor Owino[4]

- 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



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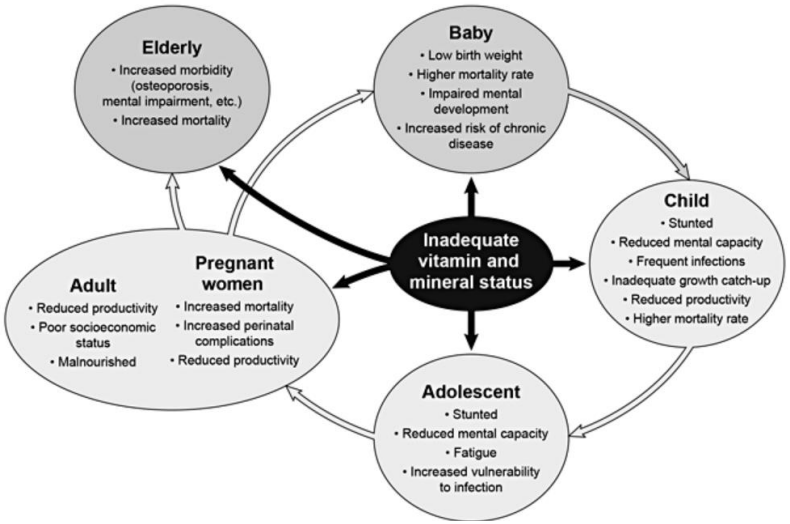
Micronutrient deficiencies

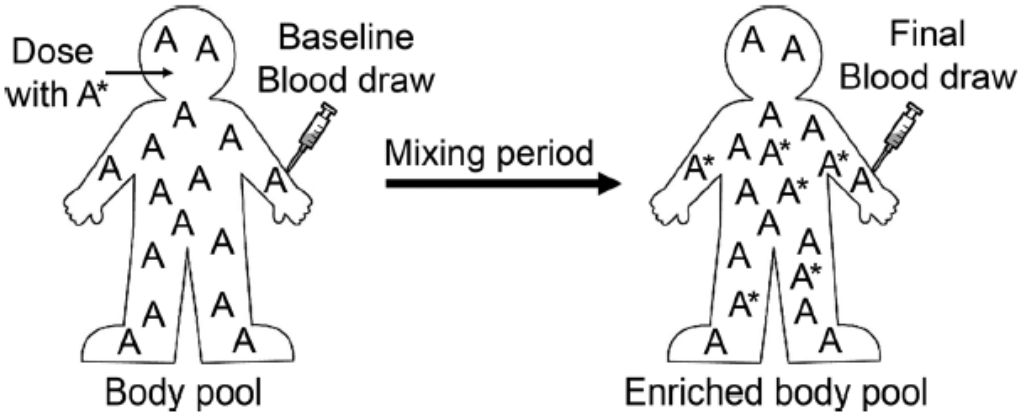
Micronutrient deficiencies have short-term and long-lasting impact across the lifespan



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

Vitamin A: Retinol Isotope Dilution – how it works



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

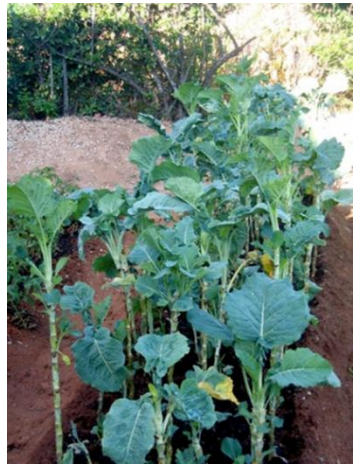
	Intervention	Control
Serum retinol, *µmol/L*		
Baseline	1.21 ± 0.19	1.18 ± 0.26
Endline	1.28 ± 0.27	1.15 ± 0.23
Total body reserves of VA, *µmol retinol*		
Baseline	153 ± 66	108 ± 67
Endline	269 ± 148*,**	124 ± 89

*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

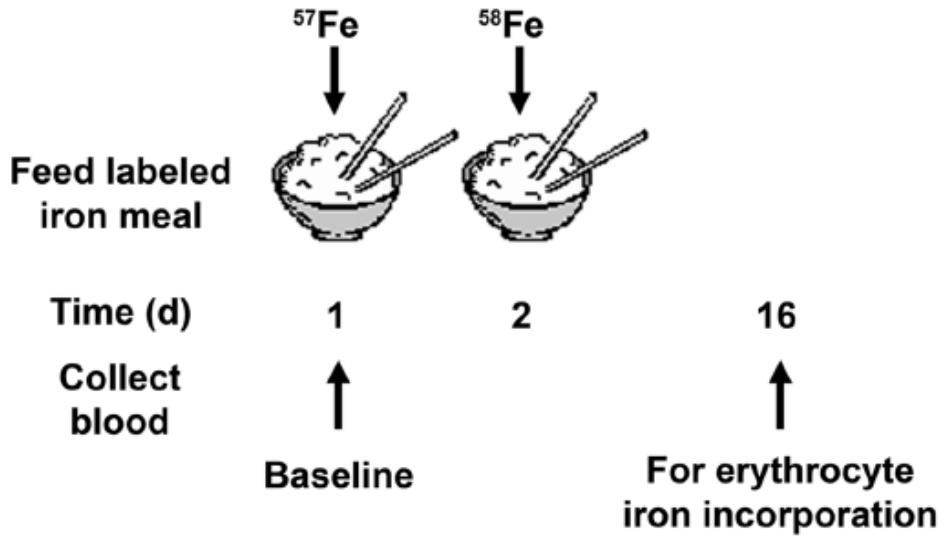
- ✓ High vitamin A value
- ✓ **Moringa leaves** (Mexico)
  Bioconversion factor of 1.47:1 by weight when prepared as puree
- ✓ **Kale** (Zimbabwe)
  Bioconversion factor of 13.4:1 or 11.0:1 by weight when pureed and prepared with peanut butter or lard
- ✓ Important source of vitamin A in preschool children



LOPEZ-TEROS V et al, J Nutr 147 (2017) 2356-63

MUZHINGI T et al, Asia Pac J Clin Nutr 26 (2017) 1039-1047

Measuring Iron Absorption – how does it work?



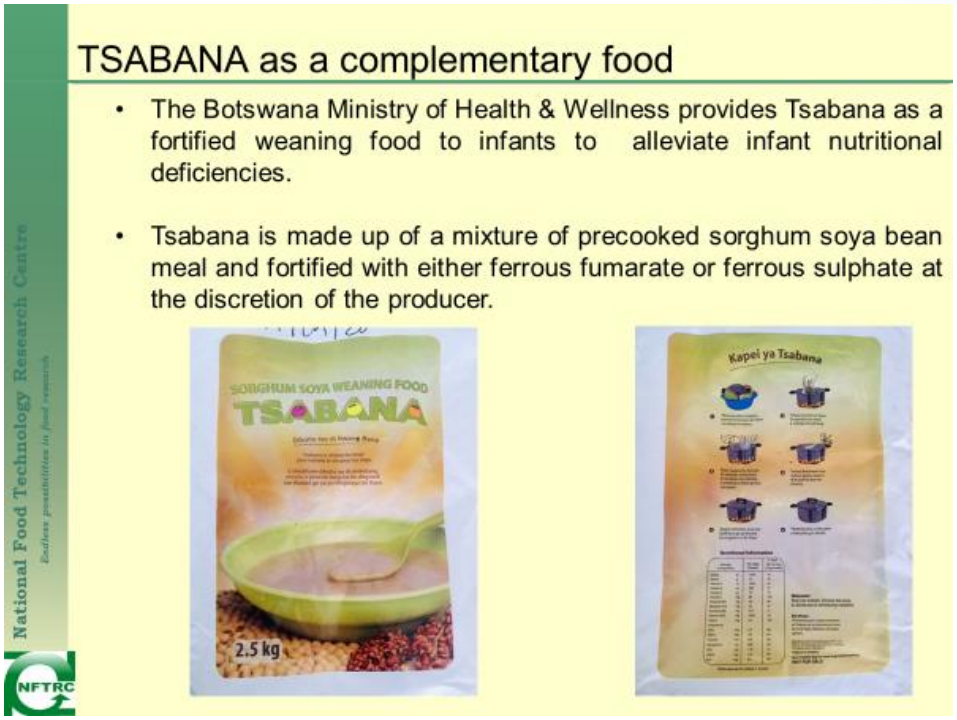
1. Fe stable isotopes added to test meals after taking 1st blood sample
2. Retention of isotopes after 2 weeks determined in blood (2nd blood sample); 80% of absorbed iron incorporated into RBCs
3. Iron is analyzed by mass spectrometry; ratios of stable isotopes compared before and after dosing to determine 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

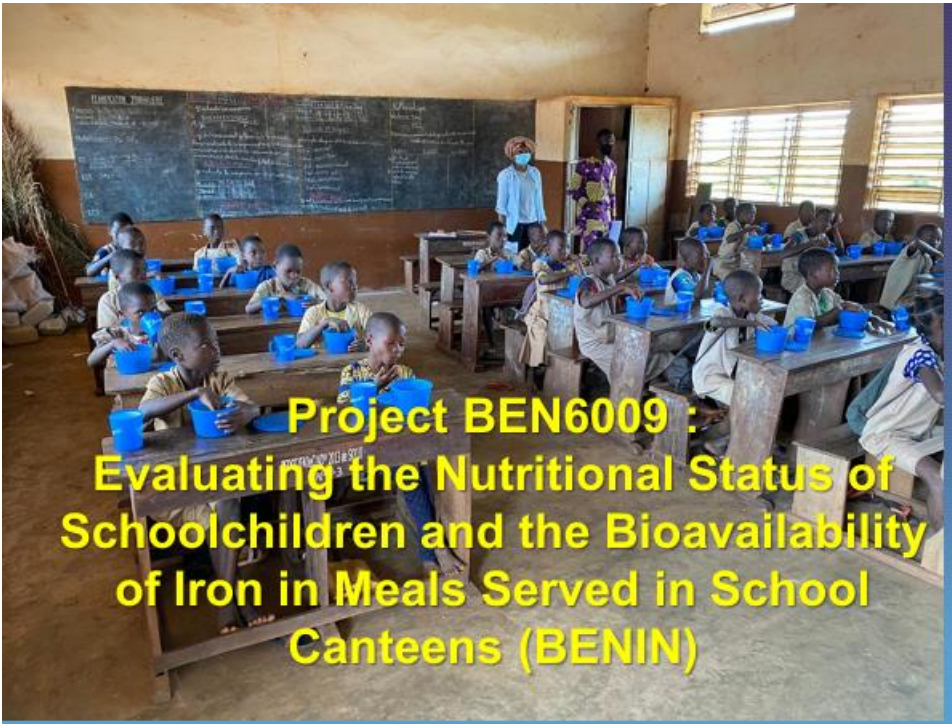
KODKANY BS et al, J Nutr 13 (2013) 1489-1493

Example from Botswana



Courtesy: Dr Boitumelo Motswagole

Example from Benin



TC BEN 6009: Implemented to date

- Inventory of the meals served in school cantines in Benin ~ **20 meals are found in the school canteens**
- 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

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Courtesy: Prof Waliou A. Hounkpatin

Example from Benin

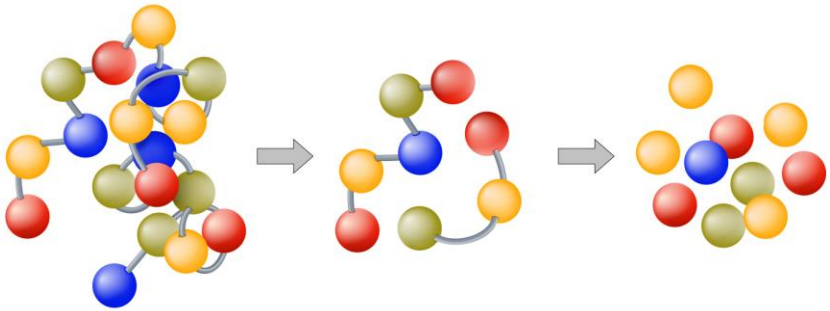
Courtesy: Prof Waliou A. Hounkpatin

Protein quality

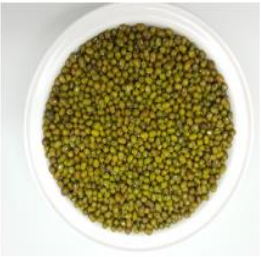
- Protein quality is the ability of a food to provide an adequate amount and balance of essential amino acids
- Protein quality is important for body structure, growth, regulation of organs and tissue function, protection against infection
- Protein inadequacy and quality significantly related to stunting 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



Plant labelled with deuterium during growth



Protein-quality evaluation of complementary foods in Indian children

Nirupama Shivakumar, Sindhu Kashyap, Satvik Kishore, Tinku Thomas, Aneesia Varkey, Sarita Devi, Thomas Preston, Farook Jahoor, M S Sheshshayee, Anura V Kurpad ✉

The American Journal of Clinical Nutrition, Volume 109, Issue 5, May 2019, Pages 1319–1327, https://doi.org/10.1093/ajcn/nqy265

Published: 28 March 2019 **Article history** ▾

› J Nutr. 2021 Oct 1;151(10):3151-3157. doi: 10.1093/jn/nxab216.

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 [1], Gerardo Martínez-Díaz [2], Érika N Ibarra-Pastrana [1 3], Sarita Devi [4], Anura V Kurpad [5], Mauro E Valencia [3]

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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)

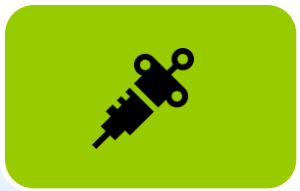
Challenges/Limitations

- 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

More information: Human Health Campus

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- Total Energy Expenditure
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- Human Milk Intake
- Vitamin A Body Pool Size
- Iron and Zinc Bioavailability
- IAEA Nutrition Factsheets, Brochures & Multimedia Material
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Nuclear Techniques in Nutrition


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Environmental Enteric Dysfunction


Double Burden of Malnutrition


DBMal Symposium 2018

NEW! Use of Stable Isotopes to Evaluate Bioefficacy of Provitamin A Carotenoids, Vitamin A Status, and Bioavailability of Iron and Zinc

https://humanhealth.iaea.org/HHW/Nutrition/index.html

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