



Addressing Child Malnutrition: Protein Quality

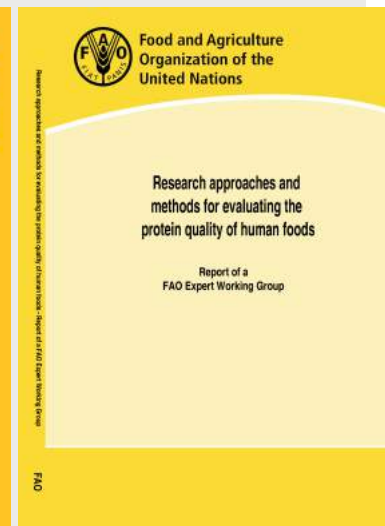
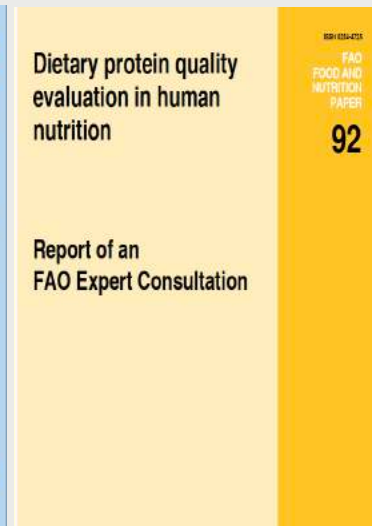
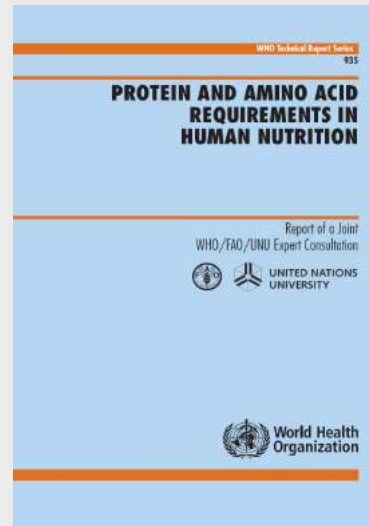
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Defining Protein Quality

- To assess the ability of a diet to meet human protein and amino acid requirements
- To assess specific protein adequacy for regulatory purposes of foods and food products sold to consumers.

Recent history of protein quality evaluation

- WHO/FAO/UNU Protein and Amino Acid Requirements, 2007
- FAO Protein Quality Evaluation in Human Nutrition. Auckland, 2013.
- FAO working group “to provide recommendations on the best methods to measure and predict digestion and efficiency of utilization of protein and amino acids. Bangalore, 2015



- Requirements to Amino Acid Scoring patterns
- Digestibility

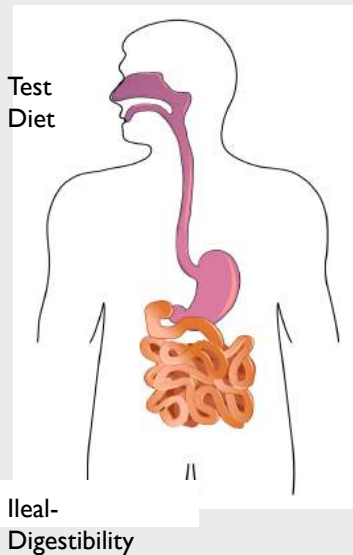
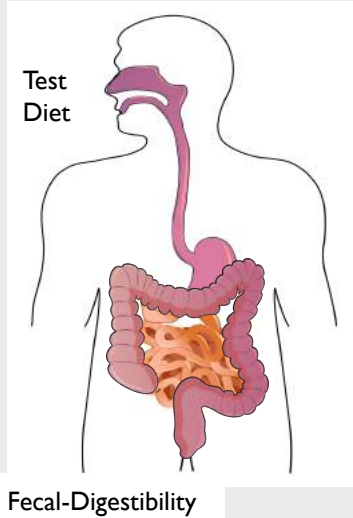
Two steps to the PDCAAS

- Define protein digestibility (PD)
 - Oro-fecal balance (WHO/FAO/UNU 2007)
 - Should be ~100%
- Define Amino Acid Score (AAS; mg IAA/g protein)
 - Protein AAS : Requirement AAS pattern
 - Requirement AAS: IAA EAR/Protein EAR
 - Ratio should be ≥ 1
- PDCAAS (Product; truncated at 100)

Salient features

- The utilization of protein will be first limited by digestibility
- The score reflects the ability of the absorbed amino acids to meet the requirement.
- The score is determined only from IAA content, but dispensable amino acids are also important in metabolic demand. PDCAAS values >100 should never be used.

FAO 2013 – PDCAAS to DIAAS



- The oro fecal balance in PDCAAS
 - unsuitable for digestibility
 - colonic microbial N
- Digestibility should be measured at the level of the ileum
 - An Ileal Digestibility term was required
 - **For each IAA**
 - Accounting for endogenous influx of IAA into the intestine
 - **“True”** Ileal Digestibility
- Digestible Ileal Amino Acid Score
 - DIAAS

Challenges

- Not much human data available
- Not available for children
- Need to test different food processing conditions
- Need to test in different environments
 - Should this be considered at all?
 - Is digestibility an “intrinsic” protein quality or should different human conditions be considered?

IAAO method for digestibility

Lysine from Cooked White Rice Consumed by Healthy Young Men Is Highly Metabolically Available When Assessed Using the Indicator Amino Acid Oxidation Technique¹⁻⁴

Ivo R. D. Prolla,^{5,6} Mahroukh Rafii,⁶ Glenda Courtney-Martin,^{6*} Rajavel Elango,⁷ Leila P. da Silva,⁸ Ronald O. Ball,^{10,11} and Paul B. Pencharz^{6,9-11*}

- Based on the indicator AA oxidation principle
- Decline in oxidation is linear with incremental test AA intake, up to requirement
- Slope of decline of oxidation is dependent on bioavailability (Metabolic Availability)
- Indexed to the slope of an AA mixture
- Oven browned rice = 70%
- Cooked white rice = 97%

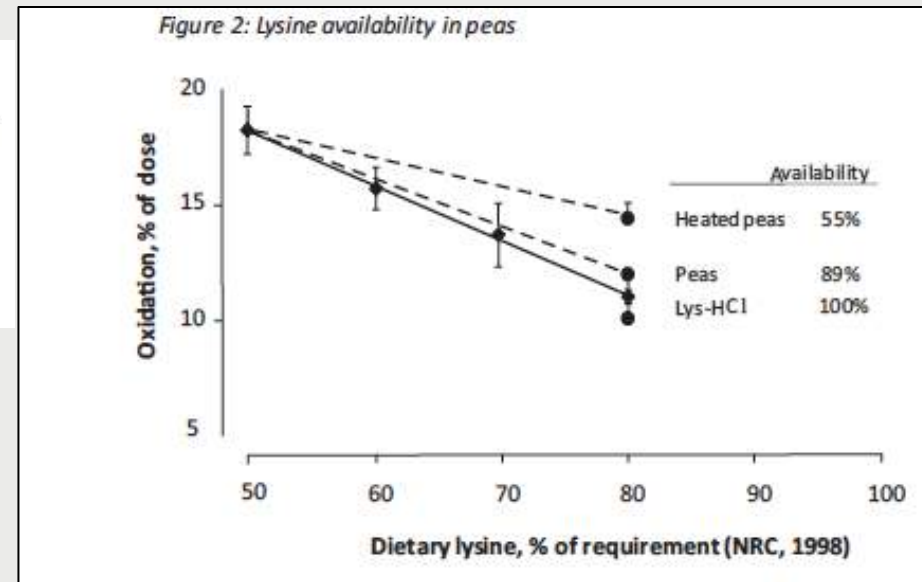


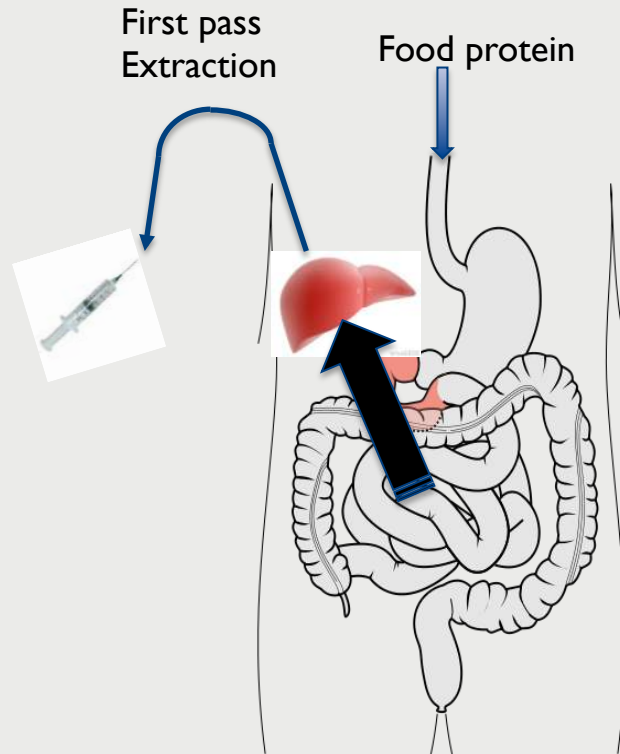
TABLE 3 MA of L-Lys in CWR and OBCR based on IAAO of L-[1-¹³C]phenylalanine¹

Lysine source	<i>n</i>	Slope equation	MA	<i>P</i>
			%	
AA mixture	5	- 0.00899 × + 1.11	100 ²	<0.01
CWR	5	- 0.00872 × + 1.11	97	<0.01
OBCR	3	- 0.00630 × + 1.11	70	0.02

¹ CWR, cooked white rice; IAAO, indicator amino acid oxidation; MA, metabolic availability; OBCR, oven-browned cooked rice.

² MA from AA mixture was assumed to be 100%.

Dual isotope method



^2H -labeled test protein
+
 ^{13}C -reference protein (known digestibility)

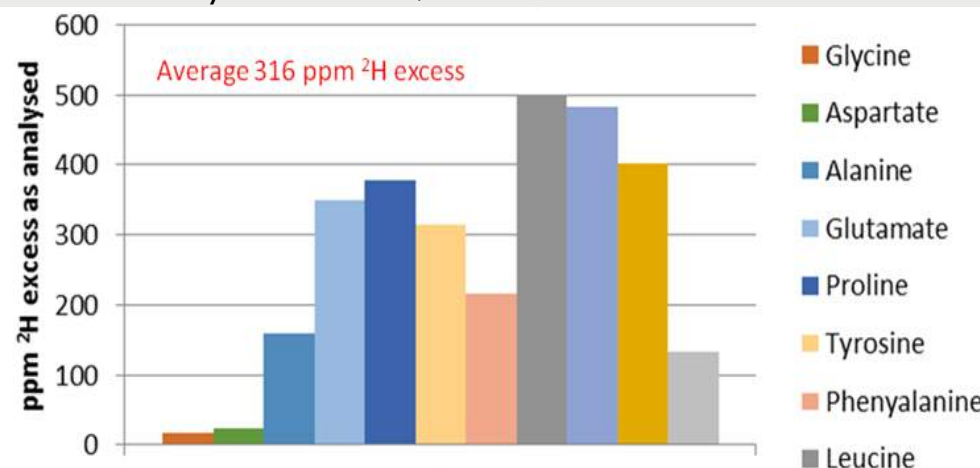
- The ratio of isotope species in the blood is an index of digestibility
- Does not get affected by liver/ splanchnic extraction

Intrinsic labelling of pulse protein (^2H)

Chickpea and mung bean at the University of Agricultural Sciences, Bangalore



Photo courtesy: Dr S Sreeman, India



The ileal digestibility of Spirulina

<u>IAA</u>	<u>MEAN</u>	<u>SD</u>	<u>CV%</u>
Methione	85.9	7.9	9
Phenylalanine	94.0	2.1	2
Threonine	87.7	9.9	11
Lysine	81.1	8.8	11
Leucine	87.5	3.7	4
IsoLeucine	83.5	4.1	5
Valine	84.8	4.2	5
<hr/> Mean	86.4		6

Measured against a mixture of crystalline ²H labelled IAA
High cv for some amino acids

Legume digestibility in an adult (n=1)
Reference protein: ^{13}C -Spirulina

IAA	Chick Pea	Whole mung bean	De-hulled mung bean
Methionine	59.8	60.6	64.1
Phenylalanine	60.5	65.2	69.4
Threonine	53.8	43.6	47.2
Lysine	44.4	56.5	57.5
Leucine	68.5	62.3	72.3
I-Leucine	68.8	76.0	80.3
Valine	64.1	64.5	78.7
Average	60.0	61.2	67.1

FAO 2013 – which digestibility value?

Human true ileal digestibility values

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graph TD; A[Human true ileal digestibility values] --> B[Growing pig - True ileal amino acid digestibility values]; B --> C[Prediction equation: human values from growing pig values]; C --> D[Growing lab rat - True ileal amino acid digestibility values]; D --> E[Faecal protein digestibility values];
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Growing pig - True ileal amino acid digestibility values

Prediction equation: human values from growing pig values

Growing lab rat - True ileal amino acid digestibility values

Faecal protein digestibility values

Scoring patterns: FAO 2013

- For infants (birth to 0.5y), the pattern of breast milk
- For young children (0.5 - 3y), the pattern for 0.5y
- For older children, adolescents and adults, the pattern for 3 - 10y old children

Challenges

- Are IAA requirements secure? Currently based on a factorial model for children
 - Protein deposition rates, efficiency of utilization
 - Catch up growth
 - Environmental effects
- Should the 0.5y IAA requirement be used for scoring in <3y children?
 - SAA requirements and legume SAA score
- Truncation – yes or no?

Key messages

- The DIAAS method is an advance over PDCAAS
- Gaps remain- Human data of True Ileal Digestibility
- Security of the IAA requirement – that derives scores
- What are the socio-environmental effects?
- What is the cost?