Protein Quality Matters!

Practical Tools to Optimize Supplemental and Therapeutic Food Formulations

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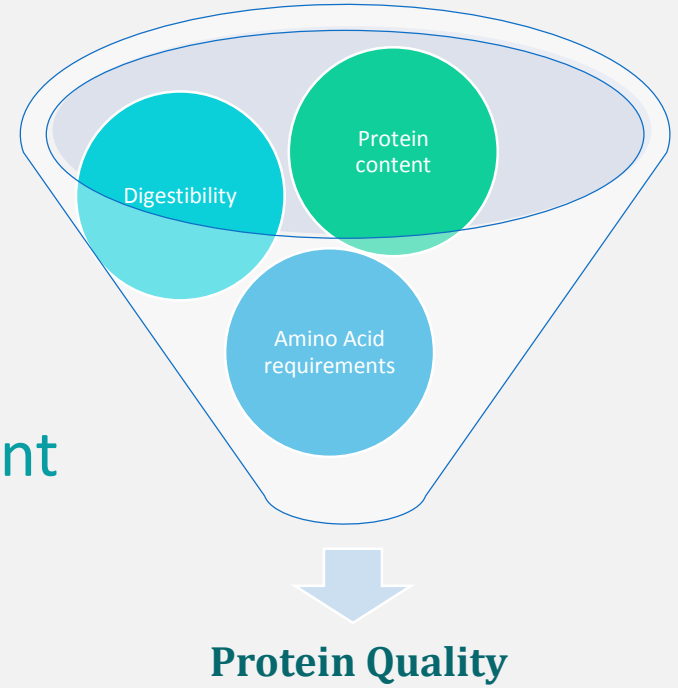
What is protein quality?

- 21 amino acids required for optimum human metabolism
  - 9 essential amino acids

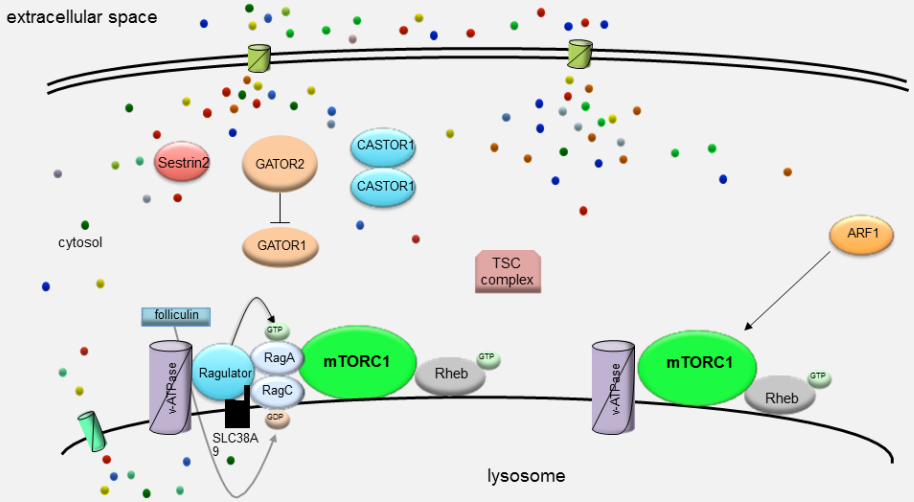
- Protein quality describes how well a protein source, mixed food, or diet provides for the body's essential amino acid requirements

- 3 components
  1. Protein content of the food
  2. Digestibility of the protein
  3. Protein (amino acid) requirement of the recipient
     - Physiologic status
     - age

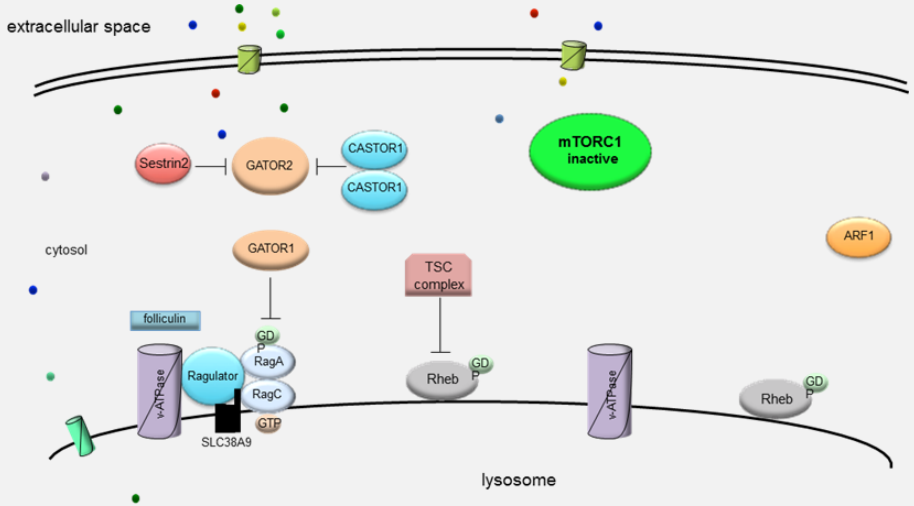


Biology of growth

A master regulator inside cells called mTORC acts as abridge between two key proteins for growth. The mTORC regulator senses the amount of amino acids and either allows growth or prevents it.



SUFFICIENT AMINO ACIDS



AMINO ACID DEFICIENCY

Protein Digestibility Correct Amino Acid Score (PDCAAS)

- Levels of protein remaining in fecal matter
- Measures digestion of crude protein
- Truncates scores to max of 1.0
- Rates protein sources against the amino acid reference pattern of a 2-5 year old child

The Digestible Indispensable Amino Acid Score (DIAAS)

- Levels of protein remaining at end of the intestine (ileum)
- Measures digestion of individual amino acids
- No truncating scores
- Differentiates between the needs of infants and children

Food Aid Products, Protein, & The Age-Old Debate: Quality vs. Quantity

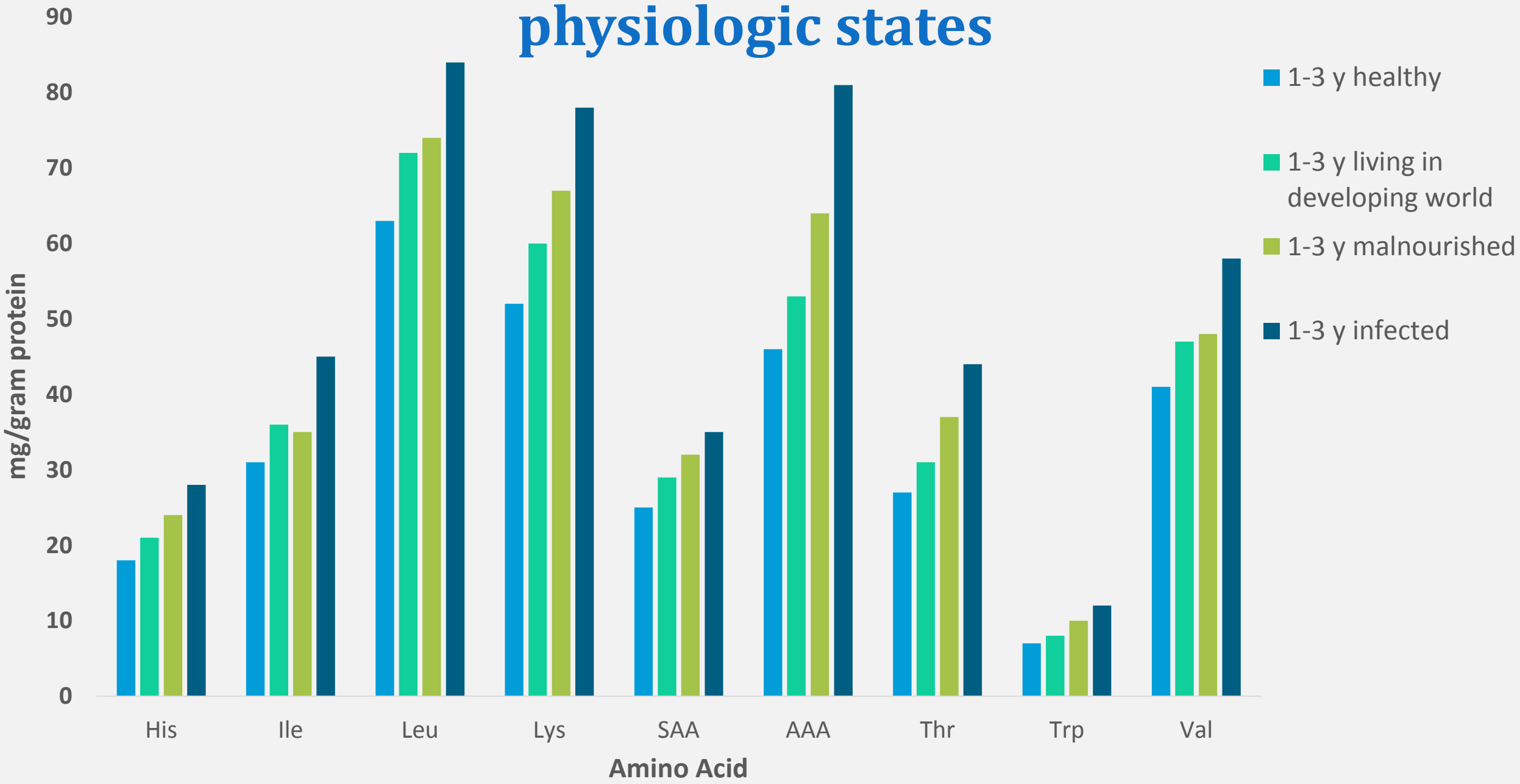
- Food aid products supplement an otherwise poor quality and limited diet, especially diets limited in protein
- Much of a food aid recipient's diet will be provided by staple rations of food products from donors
- Protein quality is often overlooked, neglected, or assumed adequate in the development of food aid products
- An easy "fix" should **NOT** be to just pack in more protein → this is an inefficient and costly approach
- Protein and amino acid requirements vary through the life cycle
- Protein quality **must** be considered in the context of the physiologic state of the recipient, this is **NOT** accounted for in the standard assessment methods

Protein Quality of Common Food Aid Products

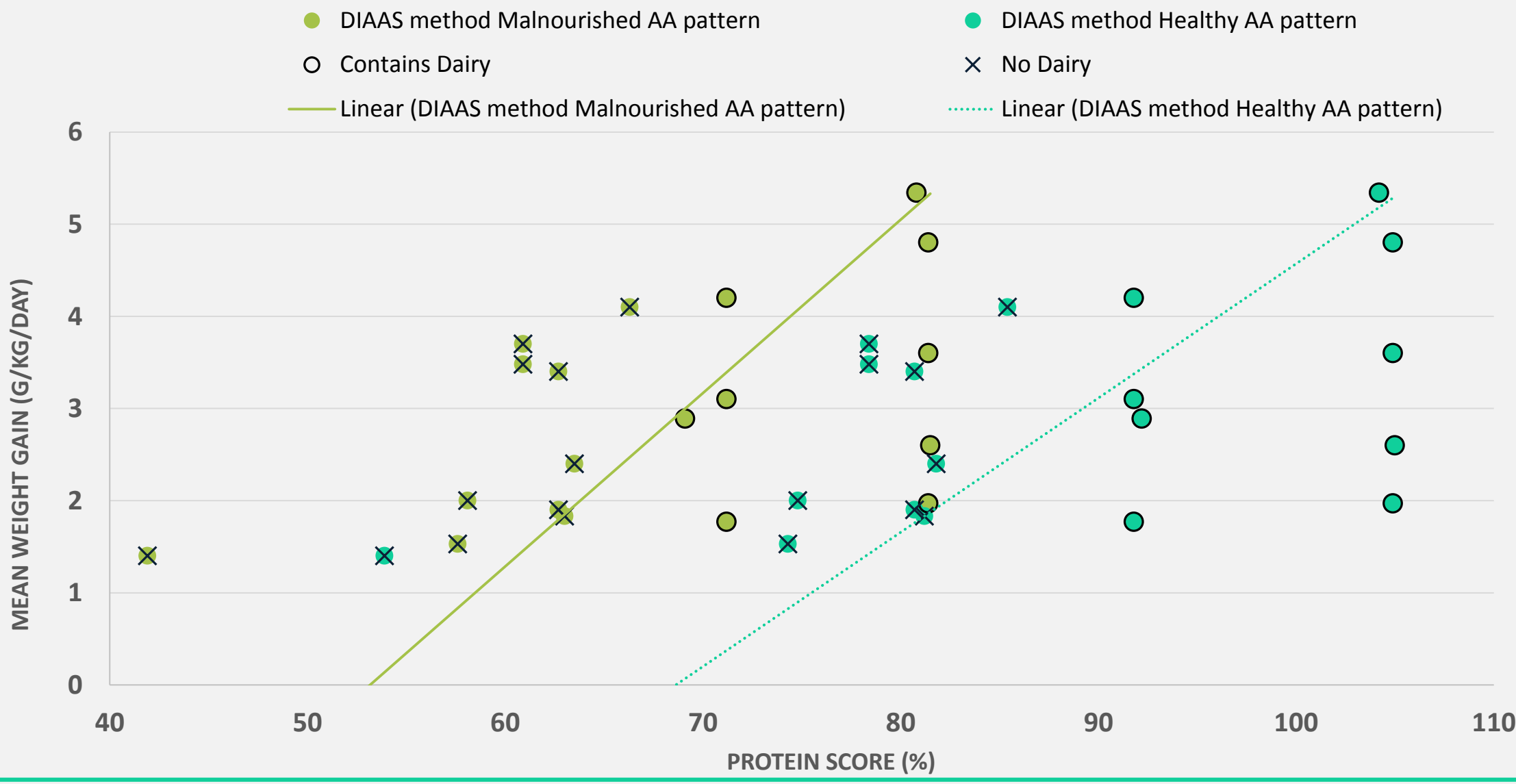
Product		PDCAAS*	DIAAS**
Severe Acute Malnutrition	Barley-Sesame RUTF	0.761	0.870
	Rice-Sesame RUTF	0.810	0.932
	Soy-Maize-Sorghum	0.935	0.909
	P-RUTF	0.985	0.950
	F75	1.000	1.318
	F100	1.000	1.318
Moderate Acute Malnutrition	CSB+	0.817	0.740
	Soy/Peanut FS	0.820	0.746
	CSB13	0.796	0.716
	Soy RUSF	0.698	0.737
	CSB++	0.906	0.848
	Milk/Peanut FS	0.992	0.958

*PDCAAS values were calculated using FAO's standard healthy 2-5 year old reference amino acid scoring
**DIAAS values were calculated using FAO's standard healthy 6 month –3 year old reference amino acid scoring

Amino Acid Scoring Patterns for 4 different physiologic states

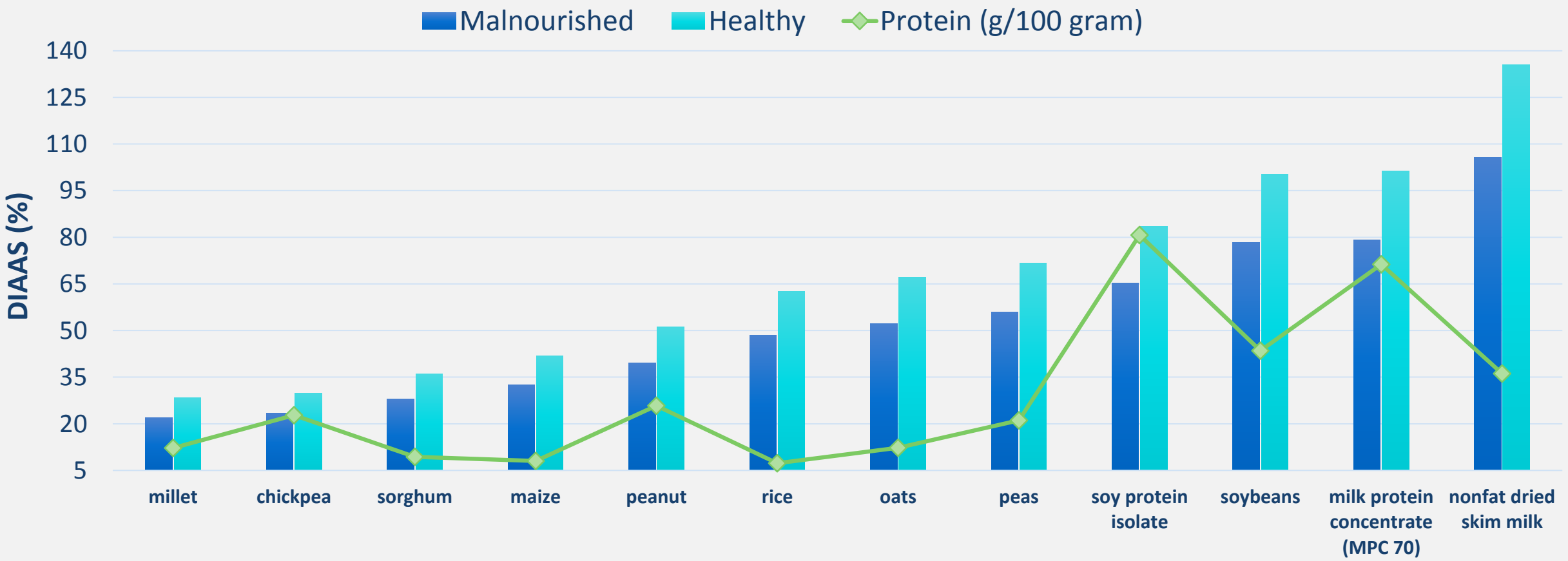


PROTEIN QUALITY OF FOOD AID PRODUCTS AND AVERAGE WEIGHT GAIN USING THE DIAAS METHOD WITH AA REQUIREMENTS FOR MALNOURISHED AND HEALTHY CHILDREN



PROTEIN QUALITY OF DIFFERENT INGREDIENTS:

DIAAS Methodology with Healthy and Malnourished Amino Acid Patterns

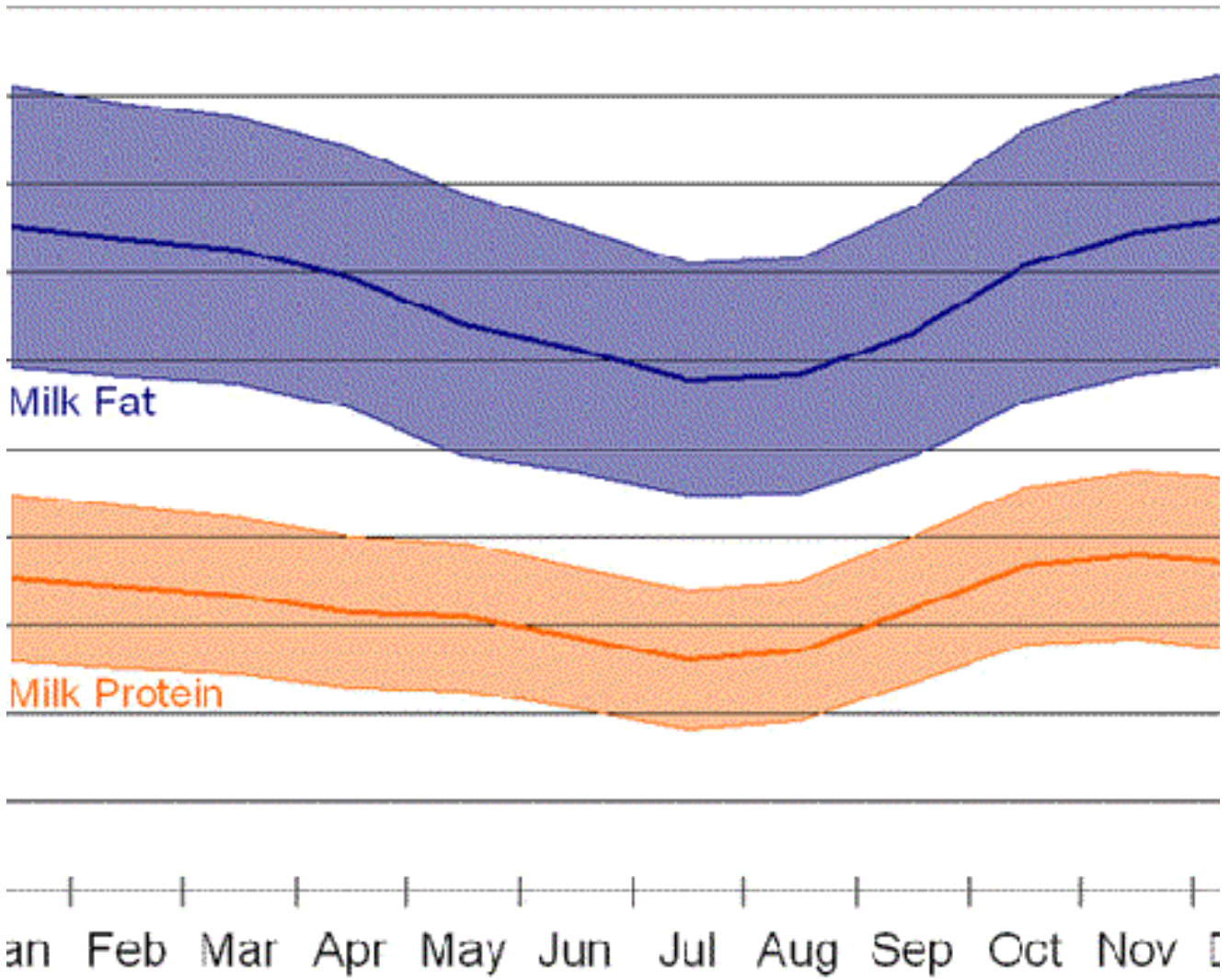


Moving protein quality into the 21st century

- Traditional methods of assessing protein quality rely on two, huge simplications:
    1. the amino acid content of given food or diet is a fixed amount
    2. the amino acid requirements of the consumer is also fixed
- Neither of these assumptions are likely to accurate.
- We have demonstrated that in food aid recipients, depending on their physiologic status, the amino acid requirements are likely to be different.

Variations in amino acid composition of the milk

- Milk from the same cows fed in the same setting fed legume fodder contained 25% more protein than cows fed grass fodder.
- While these variations are not many fold they often are 15-25%.



Nutrient Composition Variation: Affects interpretation of potential health benefits

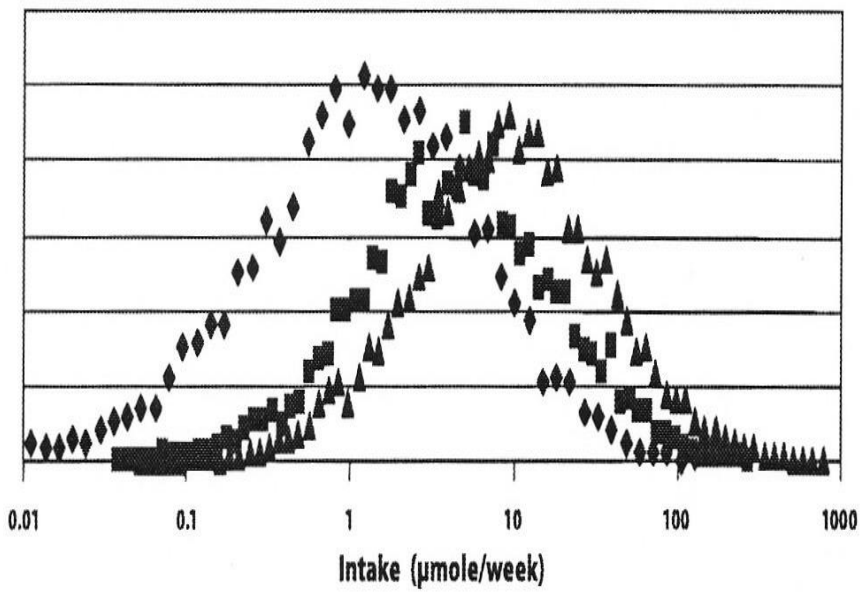
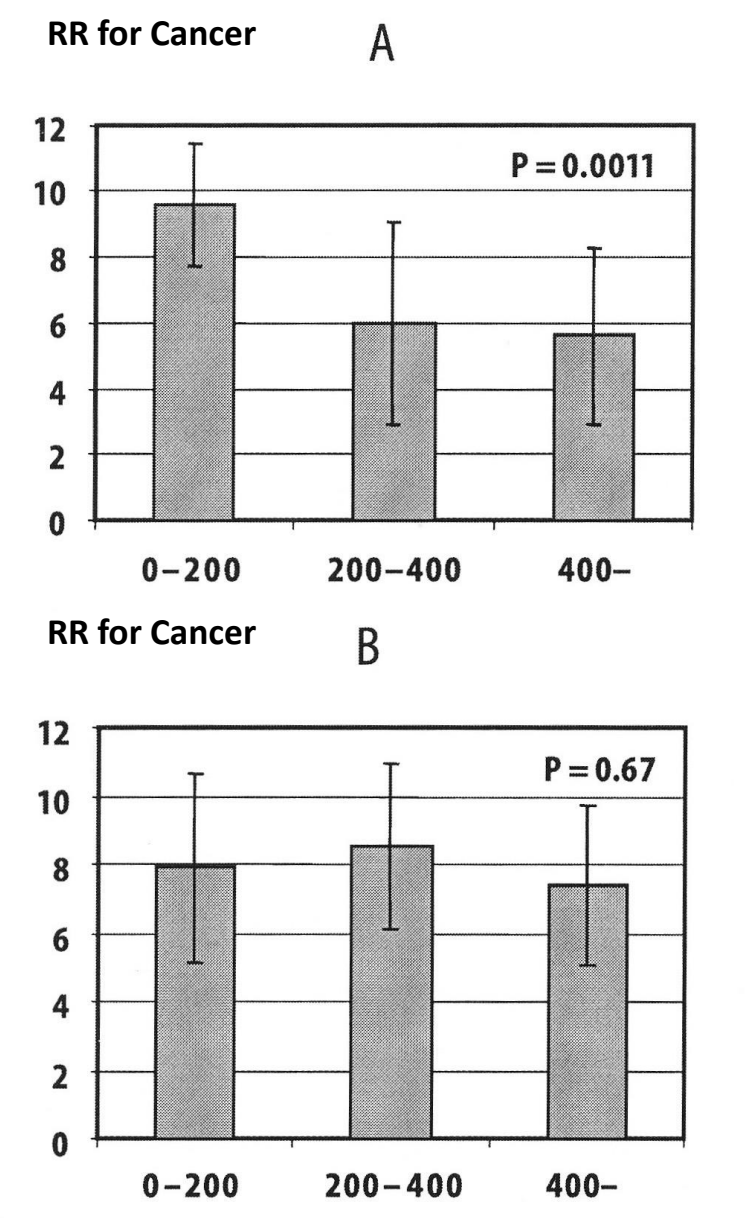


Fig. 6 Calculated glucosinolate intake of the three *Brassica* intake groups (◆: 0–200, ■: 200–400, ▲: 400–1000 g *Brassica*/week)

No Variation in Production Chain

Production Chain Variation Included



Dekker & Verkerk. *Er J Nutr* 42:67-72, 2003

“No science achieves maturity without precision data”

“Science is about measuring – preferably with something that is *not* your own eyes, which are inextricably cojoined with the baggage of your own brain: preconceived ideas, post-conceived notions, imagination unchecked… & bias.”

DeGrasse Tyson & Goldsmith: *Cosmos*, 2004

Unfortunately, Human Nutrition Today Remains an Immature Science

- “Southwest Airlines doesn’t serve food, but in surveys it is consistently rated as serving good meals.”
- Energy intake routinely under-reported by ≥ 20%
- Individual nutrient intake methods are “validated” with correlations in the 0.2 to 0.5 range.
  - That is, they are equally as bad as the prior method

Nutrition is the science of food, but we can't reliably measure food intake.

Imagine trying to truly understand diabetes without being able to accurately measure blood sugar, or renal disease without measurements of urea & creatinine, or heart disease without measuring blood flow.

André Gide

Si Le Grain Le Meurt
1924

“There are many things that seem impossible only so long as one does not attempt them.”

“Since the measuring device has been constructed by the observer…we have to remember that what we observe is not nature in itself but nature exposed to our method of questioning.”

Werner Heisenberg

We need to develop tests that can be done on humans that will quantitatively measure how much dietary intake there has been of specific foods

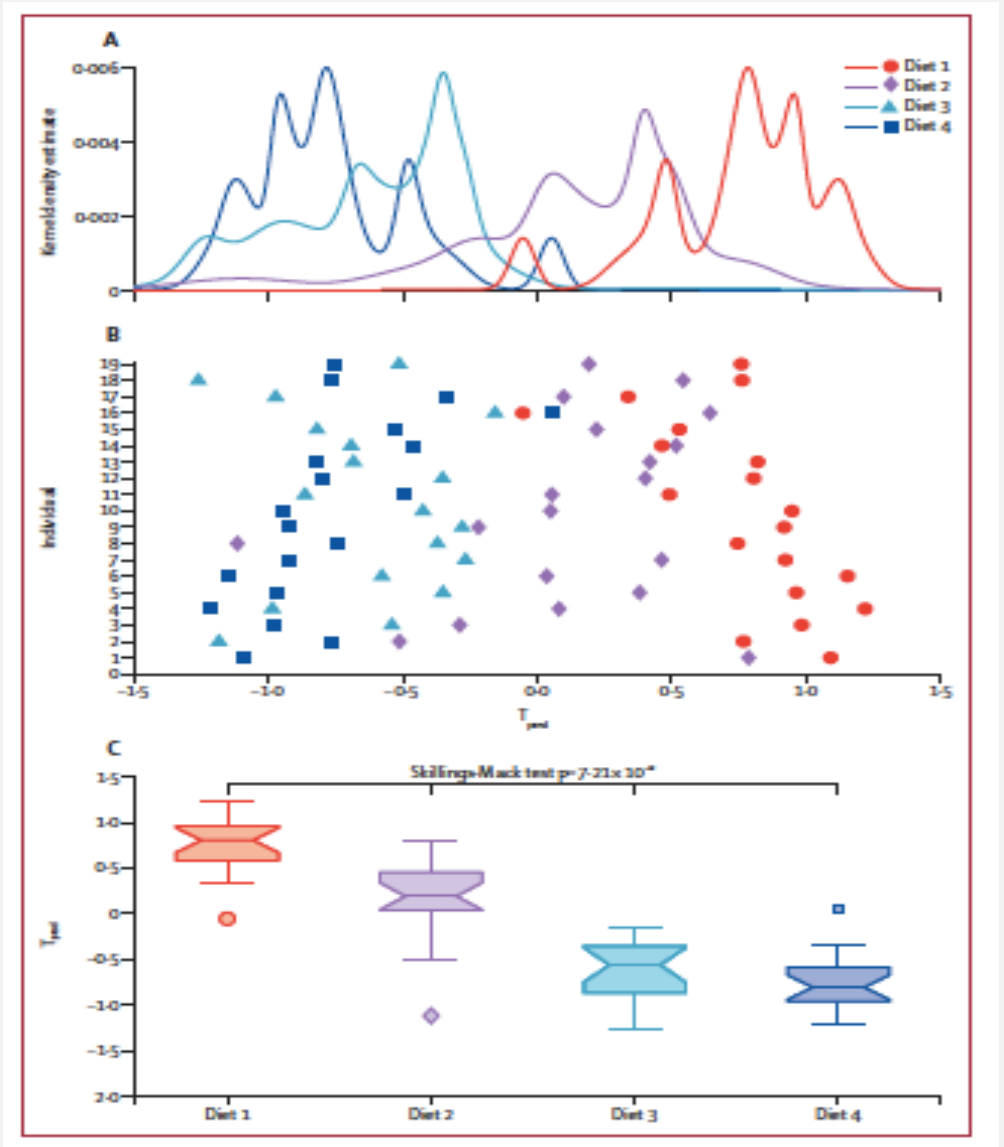
- These will be unique metabolites or patterns of metabolites found in urine or blood.
- Ability to determine multiple analytes in small volume samples in the last 10 years makes this practical.
- Agnostic testing using mass spectrometry or NMR spectroscopy can test for hundreds of compounds in a single sample.
- So rather than lots of observations, a single test will give an accurate picture of what has been consumed.
- To develop such tests trials of controlled consumption need to be conducted.

Different urinary patterns of metabolites seen in 4 controlled diets

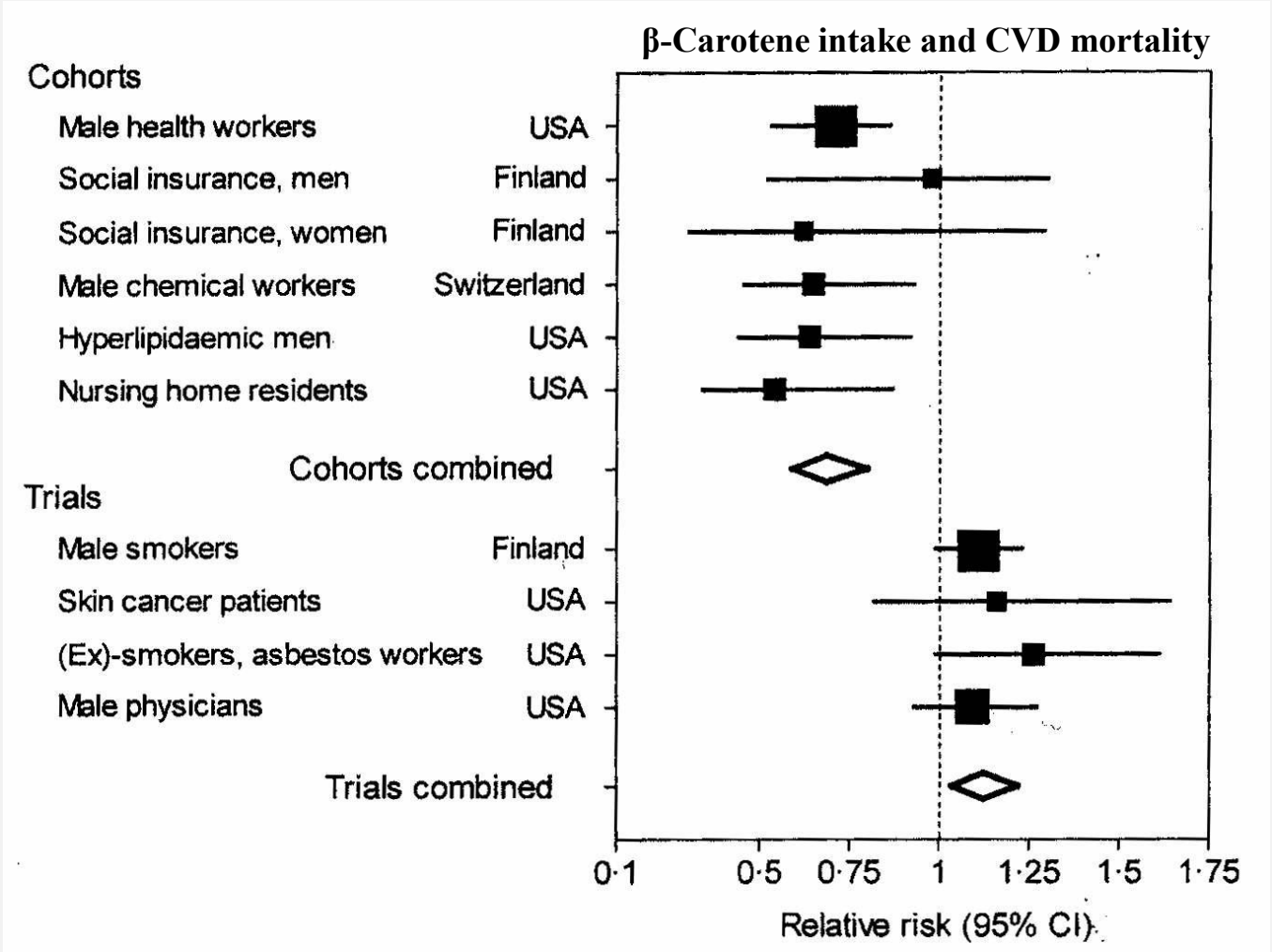
	Diet 1	Diet 2	Diet 3	Diet 4
Energy (kcal)	2260	2259	2427	2490
Energy density (kcal/g)	1·2	1·5	1·6	1·9
Proportion of protein	24%	22%	16%	13%
Proportion of carbohydrate	51%	51%	46%	44%
Total sugar (g)	14	18	22	25
Proportion of fat	23%	24%	35%	42%
Saturated fatty acids (g)	5	7	19	20
Monounsaturated fatty acids (g)	8	6	14	12
Polyunsaturated fatty acids (g)	8	5	4	2
Total trans fatty acids (g)	0·5	0·5	1	1
Fibre (g)	45·9	32·1	31·5	13·6
Sodium (mg)	2367	2261	3812	3066
Fruit and vegetables (g)	600	300	180	100
DASH score	37	30	24	11

Specific diet information (foods consumed at specific times) is shown in the appendix (p 5). DASH=Dietary Approaches to Stop Hypertension.

Table 1: Macronutrient content and characteristics of the dietary interventions



Different Views of Nature Exposed By Our Method of Questioning



M Egger et al. Systematic Reviews in Health Care. BMJ Books 2001, p 218.

“Supposing Is Good.”

Table 3. Predicted Decline in Annual Coronary Heart Disease (CHD) Events Over 10 Years Due to US Food and Drug Administration Mandated Folic Acid Fortification Based on 4 Scenarios

Percentage Reduction in Homocysteine Level, µmol/L*	Percentage Reduction in Risk of CHD†	Percentage Decrease in Myocardial Infarctions		Percentage Decrease in CHD Deaths	
		Men	Women	Men	Women
11	29	13.0	7.6	12.8	8.7
5	29	6.9	3.9	6.7	4.5
11	9	2.8	1.8	2.8	2.1
5	9	1.4	0.9	1.4	1.0

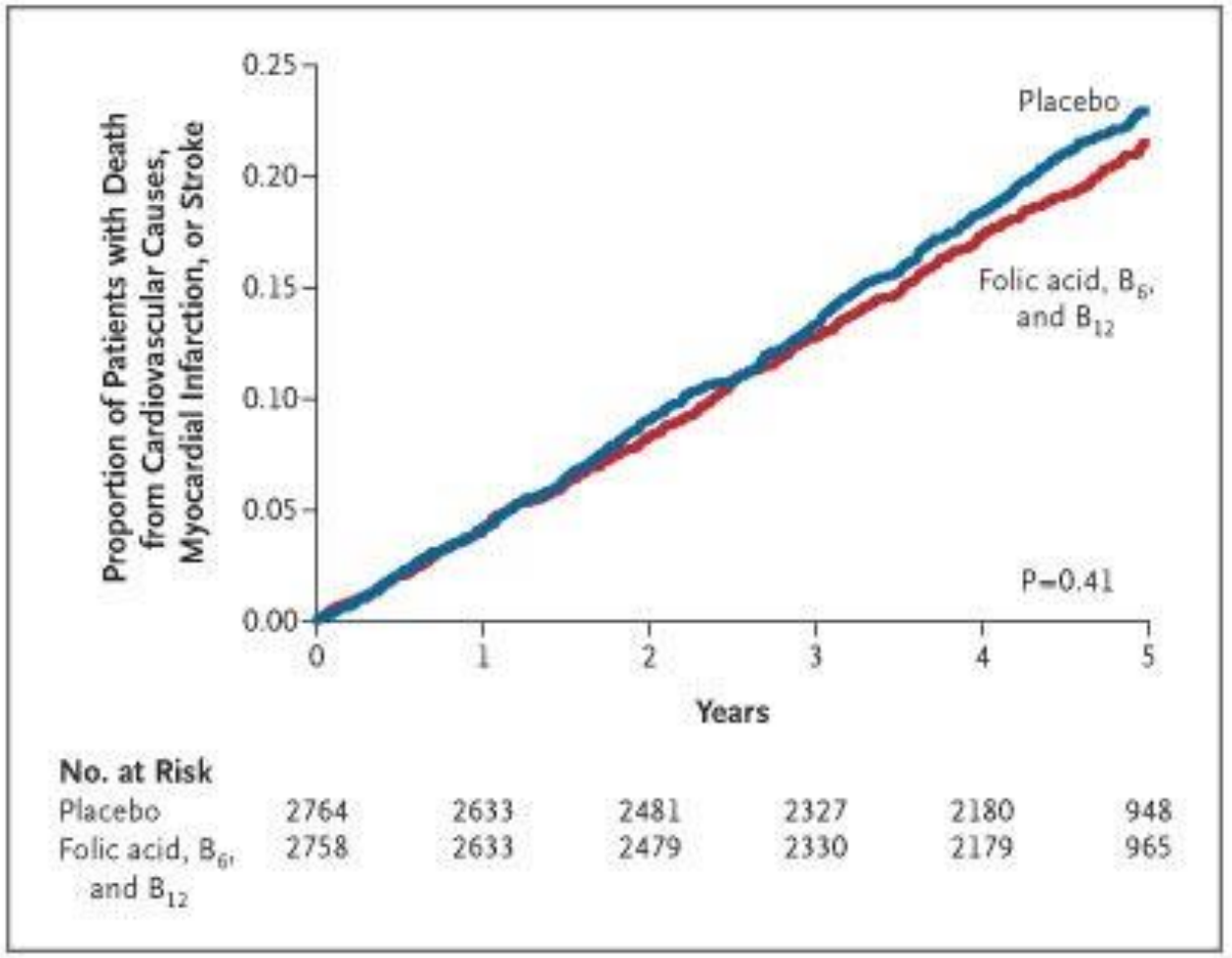
*Reduction in homocysteine levels standardized at 12 µmol/L. To convert homocysteine from µmol/L to mg/L divide by 7.397.

†Reduction in risk of CHD for each 5-µmol/L reduction in homocysteine level, 2-year delay in clinical effect.

Tice, J. A. et al. JAMA 2001;286:936-943

JAMA

“Finding Out Is Better”



The Heart Outcomes Prevention Evaluation (HOPE) 2 Investigators N Engl J Med 2006;354:1567-1577

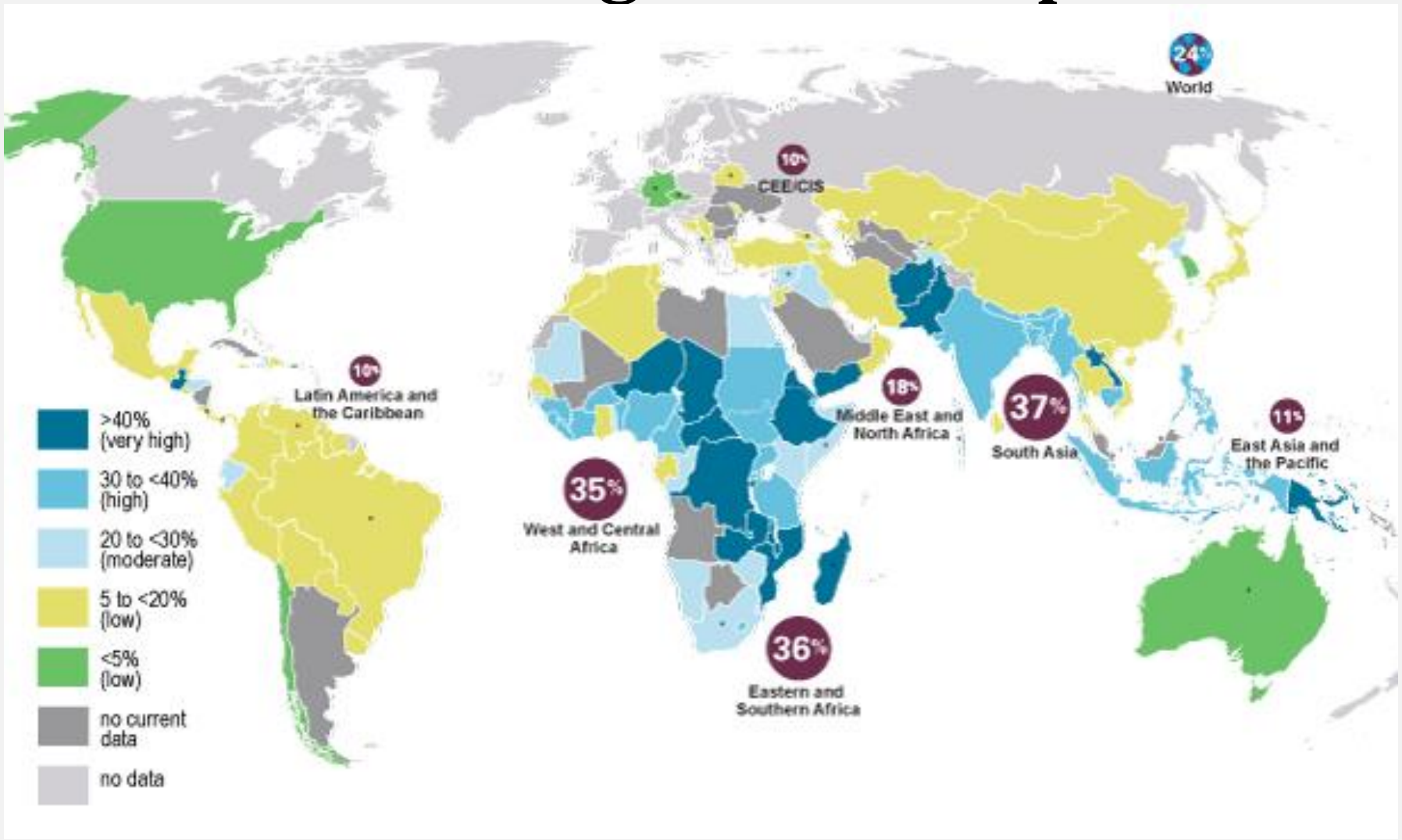
Amino acids requirements need to be defined by testing of physiological status in individuals

- Broad estimates and guesstimates based on mass balances from autopsy data are often invoked today
- Need to move to specific tests – blood or urine concentrations of amino acids or their unique metabolites that allow us to say ‘enough is being consumed’ or ’more or less is needed in the diet’
- In the last 3 years there are platforms where 180 amino acid analytes can be tested in 10 microL serum samples, giving a picture of the balance of requirements vs intake. Biocrates is such a platform using LC-MS.

Future of protein quality assessment

- A single sample is drawn from person which characterizes their diet and their protein quality requirements.
- From these data, dietary recommendations are made to improve health and well-being.
- Metabolites of specific to dairy protein consumption should be identified.
- Dairy protein is known to have a rich diversity of amino acids that are highly bioavailable, and is likely to one the most frequently recommended additions to improve protein quality.

Stunting world map



Amino acids and stunting