



Interpretation of the Protein Quality Methodology: Change to DIAAS

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DIAAS, Digestible Indispensable Amino Acid Score for assessing protein quality, will be fully endorsed upon completion of a programme of research to confirm the animal assay and to create a database of standard protein food values. In the interim, DIAAS can be estimated using published faecal crude protein digestibility values.

Executive Summary

- The nutritional value of a dietary protein source relates to the delivery of indispensable amino acids to the body
- The content, pattern and bioavailability of indispensable amino acids determine the quality of the protein
- Methods for measuring protein quality assess the ability of a dietary protein to meet human requirements for indispensable amino acids¹
- Digestible Indispensable Amino Acid Score (DIAAS) is a new assessment method that more accurately measures protein quality
- DIAAS was recommended by an FAO expert consultation on protein quality²
- DIAAS is based on the ileal digestible individual indispensable amino acids in the dietary protein relative to human reference amino acid requirement pattern
- True ileal digestibility of individual amino acids is the most accurate measurement of digestion and absorption of dietary amino acids
- The protein quality score is determined by the lowest ratio of digestible indispensable amino acid content to the corresponding indispensable amino acid in the reference pattern
- Scores may be greater than 1 (or 100%) if the protein contains a relatively high content of indispensable amino acids recognizing surplus amino acids in higher quality protein sources
- Values above 100% should not be truncated except where calculating DIAAS for protein or amino acid intakes for mixed diets or sole source foods²
- Dairy proteins are higher quality and have DIAAS values greater than 100%
- Milk powder has a DIAAS (%) of 122²
- Protein quality scores may be important in the future for adjusting/informing/understanding the available protein or amino acid content of foods
- High protein quality foods such as dairy can be used to complement foods of poorer quality for cost effective and efficient use of available foods
- DIAAS will be fully endorsed upon completion of a programme of research to generate a database of indispensable amino acids ileal digestibility values for standard protein foods.

¹ IDF Fact Sheet: Interpretation of the Protein Quality Methodology: Change to DIAAS

² FAO (2013). Food and Agriculture Organisation of the United Nations. Dietary protein quality evaluation in human nutrition. Report of the Expert Protein Consultation. Rome, 2013.

Introduction

Protein quality refers to the ability of the amino acids in foods to adequately meet human requirements for indispensable amino acids. Amino acid requirements vary for specific age groups and physiological conditions (Moughan, 2012). The consequences of inadequate protein intake to meet indispensable amino acid requirements are well known and include stunted growth, increased susceptibility to infection, suboptimal muscle capacity and diminished mental performance (from retardation to apathy). A precise assessment of the ability of a dietary protein source to match the body's needs for individual amino acids will allow better use of an increasingly scarce resource (FAO 2013). Several methods have been used to evaluate the protein quality of foods (Boye et al 2012). This factsheet considers the proposed change in methodology from the Protein Digestibility Corrected Amino Acid Score (PDCAAS) to the Digestible Indispensable Amino Acid Score (DIAAS) for assessing protein quality of human foods and ingredients.

What is DIAAS?

The recent report of the FAO Expert Consultation "Dietary protein quality evaluation in human nutrition" recommends a new, advanced method for assessing the quality of dietary proteins (FAO 2013). The Digestible Indispensable Amino Acid Score (DIAAS) replaces the Protein Digestibility Corrected Amino Acid Score (PDCAAS).

$$\text{DIAAS} = \frac{\text{mg of digestible dietary indispensable amino acid in 1 g of the dietary protein}}{\text{mg of the same dietary indispensable amino acid in 1g of the reference protein}}$$

Why are changes needed to the protein quality method?

PDCAAS is simple and has been widely used for evaluating protein quality. PDCAAS is derived from the ratio between the first limiting amino acid in the protein and its corresponding value from the amino acid reference pattern, and corrected for true faecal nitrogen (N) digestibility. However the PDCAAS has limitations (Gilani 2012; Schaafsma 2012):

- PDCAAS values are truncated to 100%, or 1, which limits high quality proteins relative to poorer quality proteins and fails to recognize the advantages of surplus amino acids to complement poorer quality proteins in mixtures
- Faecal N digestibility likely overestimates the delivery of dietary amino acids to the body
- Anti-nutritional factors in plant proteins or processed foods may lead to higher endogenous amino acids losses. Thus PDCAAS may inappropriately reflect high scores
- The amino acid reference pattern used is based on minimum requirements for growth and maintenance using the pattern for 2-5 year old children and does not reflect optimal intake.

The FAO consultation made the following recommendations:

- Amino acids should be considered as individual nutrients and their bioavailability should be considered as distinct from total nitrogen/protein availability
- PDCAAS may be acceptable for the routine evaluation of the digestibility of protein from mixed human diets containing high quality protein sources. However, it may be inappropriate for evaluating protein quality of foods that are a major proportion of the diet, eg. infant formula, enteral products, or novel or supplementary foods that contain anti-nutritional factors
- A standardised ileal amino acid digestibility assay need to be developed and confirmed
- A database of ileal amino acid digestibility values for foods should be developed.

The FAO are convening expert groups to review research needs and to develop a programme of work that will address the above questions and create the data needed to gain formal FAO endorsement of the DIAAS method. In the interim, DIAAS can be estimated using published faecal crude protein (N) digestibility values.

What are the underlying and contributing principles of the DIAAS method?

The elements of the DIAAS include amino acid requirements (the reference pattern), amino acid analysis, and measurement of ileal digestibility. There are assumptions with each of these factors.

Amino Acid reference pattern: The recommended reference pattern (FAO 2013) for use with DIAAS:

Age Group	His	Ile	Leu	Lys	SAA	AAA	Thr	Trp	Val
Scoring pattern mg/g protein requirement									
Infant (birth to 6 months)	21	55	96	69	33	94	44	17	55
Child (6 months to 3 years)	20	32	66	57	27	52	31	8.5	43
Older child, adolescent, adult	16	30	61	48	23	41	25	6.6	40

Amino Acid vs Protein Digestibility: Amino acid digestibility is similar, but not equal, to crude protein digestibility (Deglaire and Moughan 2012); digestibility of individual amino acids also varies.

Ileal vs Faecal Digestibility: There is limited capacity for dietary amino acids to be absorbed in the large intestine; amino acids that are not completely absorbed in the small intestine are utilised by the gut microbiota (Fuller 2012). High quality proteins such as dairy proteins are almost completely digested and absorbed in the small intestine and therefore have high ileal digestibility scores. However the digestion and absorption of poorer quality proteins may not be complete in the small intestine, so the disappearance of amino acids in the large intestine due to the microbiota overestimates digestibility. For this reason, ileal digestibility is a more accurate assessment of how much of the protein consumed is available to the body (Columbus and de Lange 2012).

True vs Apparent Digestibility: Endogenous contributions of protein, N, and amino acids in the gut during digestion come from enzymes, mucins, gut cells, etc (Columbus and de Lange 2012). Correcting for endogenous sources of N or amino acids in the gut gives “true” digestibility scores rather than “apparent” digestibility; uncorrected scores overestimate digestibility (Moughan and Rutherford 2012).

Effect of the Food Matrix: : The food matrix will influence the digestibility and utilisation of protein. High dietary fibre content, and anti-nutritional factors in foods can reduce the digestibility of protein and amino acids (Gilani et al 2012). Processing foods and ingredients may decrease, but not completely eliminate the activity of anti-nutritional factors, but also independently affects protein quality (Boye et al 2012). The types of processing that can affect

protein quality include germination (soaking of seeds until sprouting occurs), wet or moist heat treatment, dry heating, smoking and broiling, spray drying, extrusion, irradiation and fermentation.

Human vs Animal Models: It is not practical to estimate protein quality using the invasive ileal digestibility method in humans and therefore other methods must be identified for the routine testing of foods. Both non invasive approaches in human as well as monogastric animal models such as the rat and pig, or in vitro methods are discussed (Deglaire and Moughan 2012; Butts et al 2012; Hendriks et al 2012).

Does protein digestibility represent a valid indicator of amino acid bioavailability?

One of the limitations of protein quality assessments based on digestibility and amino acid content, whether PDCAAS or DIAAS, is that they do not assess the utilisation of amino acids after they are absorbed. McNurlan (2012) reviews the post-absorptive effects of amino acids on metabolism. Absorbed amino acids that are in excess to requirements are largely catabolised, so there is a thermogenic cost of consuming excess poor quality proteins to achieve amino acid adequacy.

Conclusion

Protein is an important nutrient and must deliver all the indispensable amino acids in the correct balance for growth and maintenance. The protein content of a food is not the only criteria for adequate human nutrition and increasingly regulators (Lewis 2012), food industry and health care professionals will recognise the relevance of protein quality. The high quality of dairy proteins relative to plant sources is better demonstrated using the more accurate DIAAS method.

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