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EDITORIAL

Current issues in determining dietary protein quality and metabolic utilization

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In resource-limited settings, poor dietary quality has a marked negative impact on health, especially during the sensitive periods of pregnancy and the first 2 years of life (the first 1000 days) when stunting, poor development and increased risk of later disease develop. Protein quality is often poor owing to high amounts of low quality cereals and little animal food. Recently there has been more focus on the protein quality of human diets.[1] In this commentary we identify gaps in the measurements of protein quality and suggest noninvasive but accurate ways forward.

Applying estimates of protein and amino acid requirements to diets in order to adequately support protein synthesis, and hence growth, involves the determination of protein quality and the effects of diet preparation on quality. For protein quality, there are two processes to consider; first, the digestion of proteins and absorption of the constituent amino acids (so called digestibility); and second, the utilization of the absorbed amino acids to support whole body protein synthesis (so called availability). These two processes encompass what may be termed the bioavailability or metabolic availability of amino acids from food protein.

At present, the judgment of protein quality is based on the comparison of its pattern of amino acids with the requirement pattern of amino acids, after adjusting for the digestibility of the protein—assuming that the digestibility of amino acids from protein would be similar to the digestion of the intact protein. This protein digestibility corrected amino-acid score (PDCAAS), based on the chemical composition of the protein, also assumes that the true digestibility of a protein (ileal digestibility, estimated from the oro-ileal nitrogen balance) can be approximated from the measurement of the oro-fecal nitrogen balance. Although pragmatic, this is an incorrect approximation, as fecal N includes contributions from secretions and colonic bacteria. Several other limitations of the PDCAAS have also been identified.[2]

In a recent FAO consultation, a theoretical new index was proposed; this overcame the limitations of the PDCAAS in terms of true measurements of ileal digestibility of individual amino acids.[3] Called the digestible indispensable amino-acid score, this specified the use of ileal digestibility measurements for individual amino acids. It is difficult to measure ileal digestibility in humans by the usual methods, and new methods are needed. However, it was clear that, although the 2011 FAO Expert Consultation favored the more current DIAAS as a superior evaluation methodology, it recognized that, until more extensive human data were available on the ileal amino-acid digestibility of human-related diets, it was not viable for practical use.

It is therefore critical that data on ileal protein digestibility, utilization or metabolic availability are developed in humans. As different diets with different cooking methods and locations need to be assessed, relatively noninvasive approaches are required. There are several potential approaches that can be developed using stable isotopes, and currently two approaches have been reported on.

The first approach involves the use of intrinsically (^{15}N, ^{13}C, ^{2}H) labelled foods. This measures mostly digestibility. Labelled dietary protein may be used to develop noninvasive approaches for studing digestion, absorption and metabolic utilization of protein-bound dietary amino acids.[4] Uniformly ^{15}N, ^{13}C and/or ^{2}H-labelled proteins from microbes or plants are produced by using ^{15}N, ^{13}C and/or ^{2}H-labelled carbon sources. Uniformly ^{15}N-labelled protein from microbes, plants or from milk is produced by using ^{15}N-labelled ammonium salts. The different labelling (^{15}N, ^{13}C and/or ^{2}H) approaches can also be combined. Dietary amino acids are transiently transferred in the body and are either used for protein synthesis or degraded, and protein efficiency can be related to nitrogen and amino-acid retention. Net postprandial protein utilization is assessed after the ingestion of a single ^{15}N- or ^{13}C-labelled mixed meal by the measurement of the fraction of dietary ^{15}N or ^{13}C transferred to urea or CO_2, respectively. This method has been used to show that the efficiency of postprandial dietary protein utilization in humans is modulated by both the protein source in the meal and the habitual protein intake. Further, the combination of $^{15}N/^{13}C$ stable isotope-labelled protein, breath sampling and urine metabolomic analysis can be used to develop noninvasive methods to measure metabolic availability of protein-bound amino acids. For this purpose, experimental data are analyzed by multi-compartment models and multivariate statistical analyses in order to correlate isotopic and metabolomics data to protein and amino acid availability. Specific biomarkers can be identified and related to protein and amino acid requirement and protein and amino-acid efficiency.

Another possibility for measuring digestibility with this approach, from ^{2}H-labelled food proteins, is to compare the absorption of ^{2}H-labelled amino acids from labelled intact protein with the absorption of ^{13}C-labelled amino acids from a (pre-digested) crystalline amino-acid mixture having the same composition as the intact protein. As it is expected that the splanchnic handling of the ^{2}H or ^{13}C amino acid would be similar, digestibility can be deduced from the ratio of enrichment of these two isotope labelled amino acids (or amino acids of interest) in the blood.

The second approach involves the oxidation of an indicator amino acid as a reflection of protein synthesis. In this method, phenylalanine is used as an indicator and its oxidation reflects the utilization of the test protein bound amino acid for protein synthesis. If utilization is better, oxidation of the indicator is less. This latter method measures overall metabolic availability.[5]

Both approaches are recent and need much wider application, that is, applying a variety of human diets and foods for all age groups and for pregnant and lactating women.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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