Assessing Protein Quality in Food: Navigating Regulations and Sources

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Disclosure Statement

• Current Grants & Contracts
  • Agriculture and Agri-Food Canada Growing Forward 2 – Private:Public Partnership with:
    • Pulse Grower Associations and processing industries
    • Cereal Grower Associations and agronomic industries
  • Natural Sciences and Engineering Research Council of Canada (NSERC)
    • Discovery Grant, Connect Grant
  • Industry Contracts and Technical Services Agreements related to Protein Quality Assessment of foods and food ingredients
  • Egg Farmers of Canada
  • Manitoba Egg Farmers
  • MITACS Canada

• Current Participation on Advisory Boards and Grant Review Panels
  • Danone Canada
  • ILSI North America – Canadian Advisory Council
  • AOAC International Editorial Board

• No financial interests in agri-food/nutrition companies
Outline

• Communicating Protein Messages
• Protein Quality: Supporting Protein Content Claims
• Current and Proposed Approaches to Measuring Protein Quality
  • Challenges and Opportunities
• Protein Quality Workshop – Overview of Key Findings
Consumers are Seeking Protein

- 64% of respondents try to consume protein
- More prevalent in women and those with higher incomes

2016 Food and Health Survey. Food Insight, May 11, 2016. International Food Information Council
Communicating Food Protein Messages

• Nutrition Facts Panel
  • Crude Protein Content
  • % Daily Value (in US)

Nutrition Facts
Valeur nutritive
Per 1 bowl (300 g) / Pour 1 bol (300 g)

<table>
<thead>
<tr>
<th>Amount</th>
<th>% Daily Value</th>
<th>Teneur</th>
<th>% valeur quotidienne</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calories / Calories</td>
<td>440</td>
<td>29 %</td>
<td>29 %</td>
</tr>
<tr>
<td>Fat / Lipides</td>
<td>19 g</td>
<td>29 %</td>
<td>21 %</td>
</tr>
<tr>
<td>Saturated / Saturés</td>
<td>4 g</td>
<td>21 %</td>
<td></td>
</tr>
<tr>
<td>+ Trans / Trans</td>
<td>0.2 g</td>
<td>21 %</td>
<td></td>
</tr>
<tr>
<td>Cholesterol / Cholestérol</td>
<td>35 mg</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sodium / Sodium</td>
<td>880 mg</td>
<td>36 %</td>
<td></td>
</tr>
<tr>
<td>Carbohydrate / Glucides</td>
<td>53 g</td>
<td>18 %</td>
<td></td>
</tr>
<tr>
<td>Fibre / Fibres</td>
<td>4 g</td>
<td>16 %</td>
<td></td>
</tr>
<tr>
<td>Sugars / Sucres</td>
<td>6 g</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Protein / Protéines</td>
<td>15 g</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vitamin A / Vitamine A</td>
<td>45 %</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vitamin C / Vitamine C</td>
<td>4 %</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Calcium / Calcium</td>
<td>20 %</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Iron / Fer</td>
<td>20 %</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

• Claims
  • Origin Claims
  • Composition Claims
  • Symbols
  • Nutrient Content Claims
  • Source → Excellent Source
  • Comparative Claims

High in Protein

Excellent Source of Protein
What Evidence is Needed to Support Content Claims?

Quantity vs. Quality

- Nitrogen Content
- Nitrogen Conversion Factor
  - Per Weight or Volume basis
  - Per % Energy basis
- Amino Acid Composition
- Digestibility/Availability of Amino Acids for Metabolic Work
## What Evidence is Needed to Support Content Claims?

<table>
<thead>
<tr>
<th>Jurisdiction</th>
<th>Basis for Protein Content Claims</th>
<th>Methodology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Canada</td>
<td>Protein Quality &amp; Quantity</td>
<td>Protein Rating System based on the Protein Efficiency Ratio (PER)</td>
</tr>
<tr>
<td>United States</td>
<td>Protein Quality &amp; Quantity</td>
<td>Protein Digestibility-Corrected Amino Acid Score (PDCAAS)</td>
</tr>
<tr>
<td>European Union</td>
<td>Protein Quantity</td>
<td>Expression of protein content relative to energy content</td>
</tr>
</tbody>
</table>

**Proposed Method:** Digestible Indispensable Amino Acid Score (DIAAS)
Establishing Evidence for Protein Content Claims

Protein Quality Assessment

- Proportion of Essential Amino Acids (PER)
- Protein Digestibility and Availability (PDCAAS)
- Protein Digestibility and Availability Adjusted for Amino Acid Composition (DIAAS)

**How well does the amino acid pattern match human amino acid needs?**

**To what extent are the amino acids digested, absorbed and ultimately made available for metabolic demands?**
The Protein Rating Approach

- Based on Protein Efficiency Ratio
  - Rat bioassay
  - Weight gain/Protein intake over 28 days
- Adjustments relative to reference protein (Casein)
  - Adj. PER of Casein = 2.5
- Protein Rating = PER x Protein Contained in Reasonable Daily Intake
  - 20 -> 39.9 = Source of Protein
  - 40 and above = Excellent Source of Protein

Eggs

Protein Rating = 100 g x 12.63% x 3.1
= 39.2 (Good Source)
The Protein Rating Approach

Advantages

• Simple
• Provides a summative biological response to protein intake

Disadvantages

• Rodent bioassay → not reflective of human amino acid needs
• Ethical constraints
• Limited data available
  • 47 entries in the CFIA PER table
  • 184,022 foods in USDA Food Composition Databases
• Non-additive
  • Limits predictions for new food products
The PDCAAS Approach

Product of:

• Amino Acid Score (AAS)
  o AA in food/AA in reference pattern
    o mg/g protein
    o Reference pattern of 2-5 yr old school children (1991)

• True Fecal Protein Digestibility (TFPD)
  o Fecal N output/Dietary N input
    o Corrected for endogenous losses
The PDCAAS Approach

Protein Content Claims

• PDCAAS x Protein content of “RACC”
  • Representative amount customarily consumed

• Compare to Daily Value (50 g)
  • 5 – 9.9 g = Good Source
  • 10 g or greater = Excellent Source

Eggs

50 g x 12.63% x 1.0 = 6.32 (Good Source)
The PDCAAS Approach

Advantages

• Simple
• Robust AA datasets
• Additive
  • Permits calculations of PDCAAS values of mixtures

Disadvantages

• Rodent bioassay → not reflective of human amino acid needs
• Fecal protein digestibility
  • Impact of gut microbiota
• Ethical constraints
• Truncation of values > 1.00
Hot Topics on Protein: All Pros, No Cons?
ILSI North America Annual Meeting 2017

PER vs. PDCAAS

In Canada:
• CFIA will permit PER values to be calculated from PDCAAS
  
  \[
  \text{Calc. PER} = \frac{\text{PDCAAS (Test)}}{\text{PDCAAS (Casein)} \times 2.5}
  \]

Various Pulses/Cereals & Processing Methods

PER vs. PDCAAS

\[
Y = 0.3415X + 0.006442
\]

\[r^2 = 0.64\]

Calculated vs. Measured Adjusted PER Values

Various Pulses/Cereals & Processing Methods

Quadratic Fit; \(R^2 = 0.442\)
The DIAAS Approach

Dietary protein quality evaluation in human nutrition

Report of an FAO Expert Consultation

The assessment of amino acid digestibility in foods for humans and including a collation of published ideal amino acid digestibility data for human foods

Members of the Sub-Committee:

Report of a Sub-Committee of the 2011 FAO Consultation on “Protein Quality Evaluation in Human Nutrition” on:

Research approaches and methods for evaluating the protein quality of human foods

Proposed Approach – Has yet to be adopted by any jurisdiction
The DIAAS Approach

Proposed Approach

• AA treated as individual nutrients
• Uses ileal digestibility values
• Scores >1.00 are not truncated

Advantages

• Should be more reflective of the ability of a food to provide available protein

Disadvantages

• Bioassay
  • Ethical constraints
• Multiple analyses required for one DIAAS value
### Methods Comparison

**Technical Considerations**

<table>
<thead>
<tr>
<th>Quantity vs. Quality</th>
<th>Analytical Issues</th>
<th>Choice of Species</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1" alt="Balance" /></td>
<td><img src="image2" alt="Chemical Structures" /></td>
<td><img src="image3" alt="Animals" /></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Digestibility vs. Availability</th>
<th>in vivo vs. in vitro</th>
<th>The Numbers</th>
</tr>
</thead>
</table>
| ![Digestion Process](image4)   | ![In vivo vs. In vitro](image5) | Reference Pattern  
Serving Size  
Threshold Values  
Conversion Factors |
## Methods Comparison

### Other Considerations

<table>
<thead>
<tr>
<th>Social License</th>
<th>Cost</th>
<th>Variability</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1" alt="Social License Image" /></td>
<td><img src="image2" alt="Cost Arrow" /></td>
<td><img src="image3" alt="Variability Graph" /></td>
</tr>
</tbody>
</table>

- Breeding
- GMO
- Nutrition
- Climate
- Novel Processes
- Modifications

- Genetics (Plant/Animal)
- Environment
- Processing

**Social License**
- Against animal testing

**Cost**
- Increase

**Variability**
- Graph with peaks and troughs

*ILSI North America Annual Meeting 2017*
Protein Quality Workshop – Addressing Research Gaps
November 16, 2016, Toronto, ON

Featured Speakers:
- Nora Lee, Health Canada
- Blakely Fitzpatrick, US FDA
- Sarwar Gilani, Consultant

Program in Food Safety, Nutrition and Regulatory Affairs (PFSNRA)

Nutritional Sciences
UNIVERSITY OF TORONTO

Health Canada

Commodity Association

Government

Academia

Food Industry

Other (please specify)
Workshop – Key Themes

- Harmonize approaches used across jurisdictions
  - Provide certainty, affordability, accessibility, predictability
- Address significant research gaps
  - Does measuring protein quality address a human health concern
    - Dietary patterns vs. special purpose foods (RUTF)
  - Alternatives to *in vivo* assays?

White paper being prepared for publication