

Proteinkvalitet: Fra teori til praksis i den grønne omstilling

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A glass globe of the Earth is the central focus, resting on a lush, mossy forest floor. The globe is surrounded by various green plants, including ferns and small grasses. Sunlight filters through the trees in the background, creating a soft, glowing effect with lens flare. The overall scene is vibrant and natural, symbolizing environmental sustainability and green transformation.

PROTEIN KVALITET – AKTUELT I DEN GRØNNE OMSTILLING

Nutrition Research Review, page 1 of 17
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Dietary protein requirements and recommendations for healthy older adults: a critical narrative review of the scientific evidence

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Abstract
 Adequate protein intake is essential for maintenance of whole-body protein mass. Different methodological approaches account to variations in the evidence for the current protein recommendations, and it is controversially debated whether older adults require more protein to maintain the age-dependent loss of muscle mass (atrophy). Thus, the purpose of this critical narrative review is to outline and discuss differences in the approaches and methodologies assessing the protein requirements and, hence, resulting in inconsistencies in current protein recommendations for healthy older adults. Through a literature search, the narrative review first considered the historical development of the Food and Agriculture Organization/World Health Organization/United Nations University coding of protein requirements and recommendations for healthy older adults. Therefore, we discuss the weaknesses of studies (experimental studies and protein turnover based measurements) and applied methodologies of approaches forming the basis and the different recommendations with focus on healthy older adults. Finally, we discuss important factors to be considered in future studies to obtain evidence for international agreement on protein requirements and recommendations for healthy older adults. We conclude by proposing future directions to determine 'real' protein requirements and recommendations for healthy older adults.

Key words: Ageing; Amino acids; Protein synthesis; Protein breakdown; Net protein balance; Protein turnover; Metabolic adaptation; Energy balance; Protein intake

(Received 1 February 2023; revised 11 October 2023; accepted 14 October 2023)

Introduction
 Adequate protein intake is required for the maintenance of whole-body protein mass. The protein mass in a 70 kg adult is about 11 kg. Whole-body protein mass maintenance relies on equal rates of protein synthesis and breakdown, resulting in a zero net balance. The constant kinetics of protein synthesis and breakdown of body proteins were originally demonstrated by Schoenberg and colleagues in 1939⁽¹⁾ and were termed protein turnover, which is a metabolic and adaptable process. In adult humans, the daily whole-body protein turnover rate is 2.5 g/kg body weight⁽²⁾, meaning that approximately 400 g of whole protein are turned over every day for a 70 kg adult individual. Indeed, the number of amino acids are recycled and available for protein synthesis⁽³⁾, whereas some are lost as oxidized or energy products and the formation of urea to excrete nitrogen⁽⁴⁾. Further, nitrogen-containing compounds such as amino acids, nucleic acids, creatine, and urea are lost via dietary protein, which forms the basis for the recommended dietary protein intake.

It is well established how much dietary protein should be ingested to account for nitrogen excretion in healthy adults using nitrogen balance methodology⁽⁵⁾. However, this conclusion is less absolute⁽⁶⁾ whether increasing dietary protein intake in older age is an effective strategy to counteract the age-dependent loss of muscle mass⁽⁷⁾ and strength⁽⁸⁾, a phenomenon termed sarcopenia⁽⁹⁾. However, an increase in the dietary protein recommendations for older adults would compare numerous people as being protein malnourished and thereby increase the incidence of protein malnutrition worldwide. Such a change would challenge nutritional guidelines and national societies and have governments to act with excessive socioeconomic consequences. Thus, it is of utmost importance that we adopt a critical approach to the evidence

Proteinbehov og -anbefalinger igennem tiden

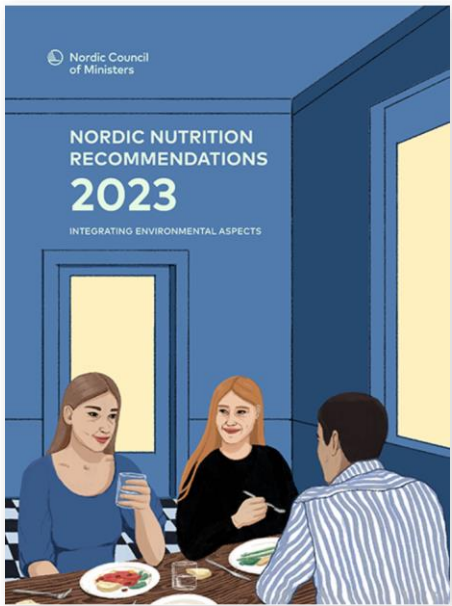
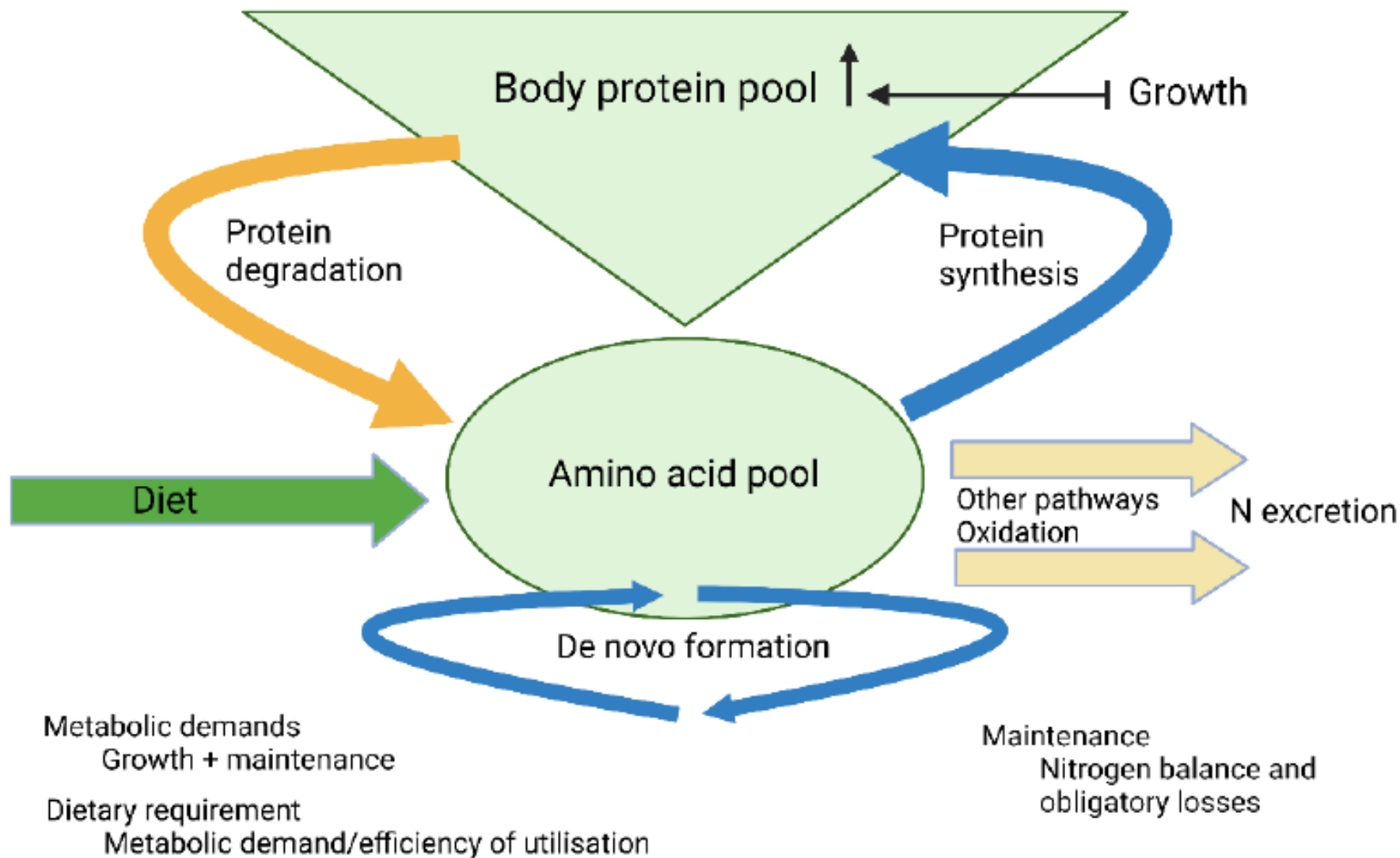
Table 1. Successive protein requirements and recommendations by international groups to ensure nitrogen balance in adults

Report	Age	Methodological approach	Biological value of dietary protein (%)	Average protein requirements (g/kg/day)	Recommendation/safe level of intake (g/kg/day)
League of Nations 1936 ⁽²²⁾	Adults	–	–	–	1.0
FAO 1957 ⁽²³⁾	Adults	N-balance	80	0.53	0.66
FAO/ WHO 1965 ⁽¹⁴⁰⁾	Adults	Factorial	80	0.71	0.89
FAO/ WHO 1973 ⁽⁹⁴⁾	Adults (20-39 yrs.)	Factorial	75	0.57	0.75
FAO/ WHO/ UNU 1985 ⁽⁹⁵⁾	Adults	N-balance	100	0.6	0.75
FAO/ WHO/ UNU 2007 ⁽⁶⁾	Adults (≥ 18 yrs.)	Meta-analysis (N-balance studies) ⁽⁷⁾	100	0.66	0.83

Adopted from NS Scrimshaw⁽¹⁴¹⁾ and updated.

Nishimura et al (2023). *Nutr. Res. Rev.*
 doi:10.1017/S0954422421000329

Omsætning af proteiner og aminosyrer i kroppen



Målgrupper, hvor proteinkvaliteten i kosten kræver særlig opmærksomhed

Ældre

Syge

Småtpisende

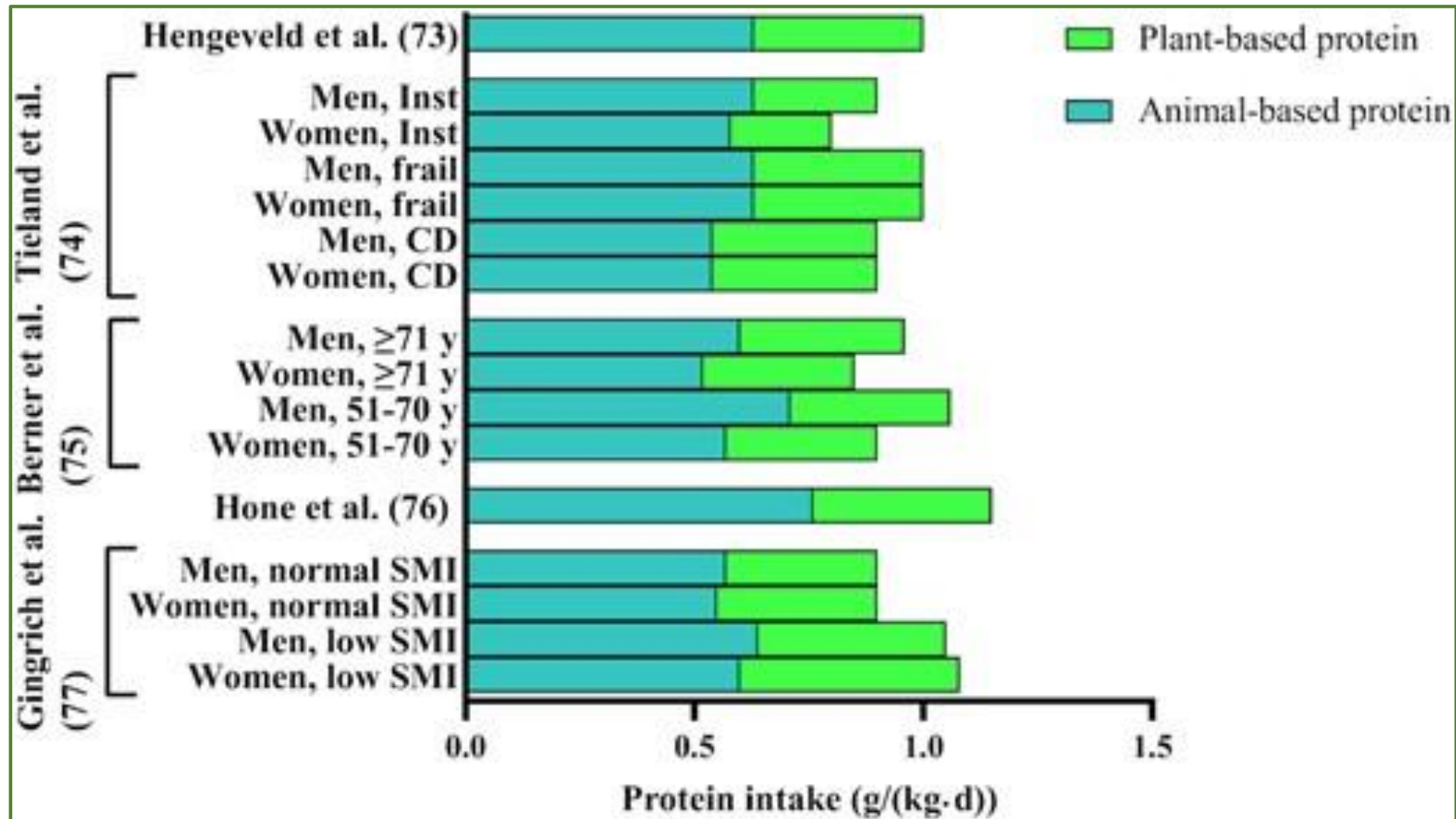
Børn

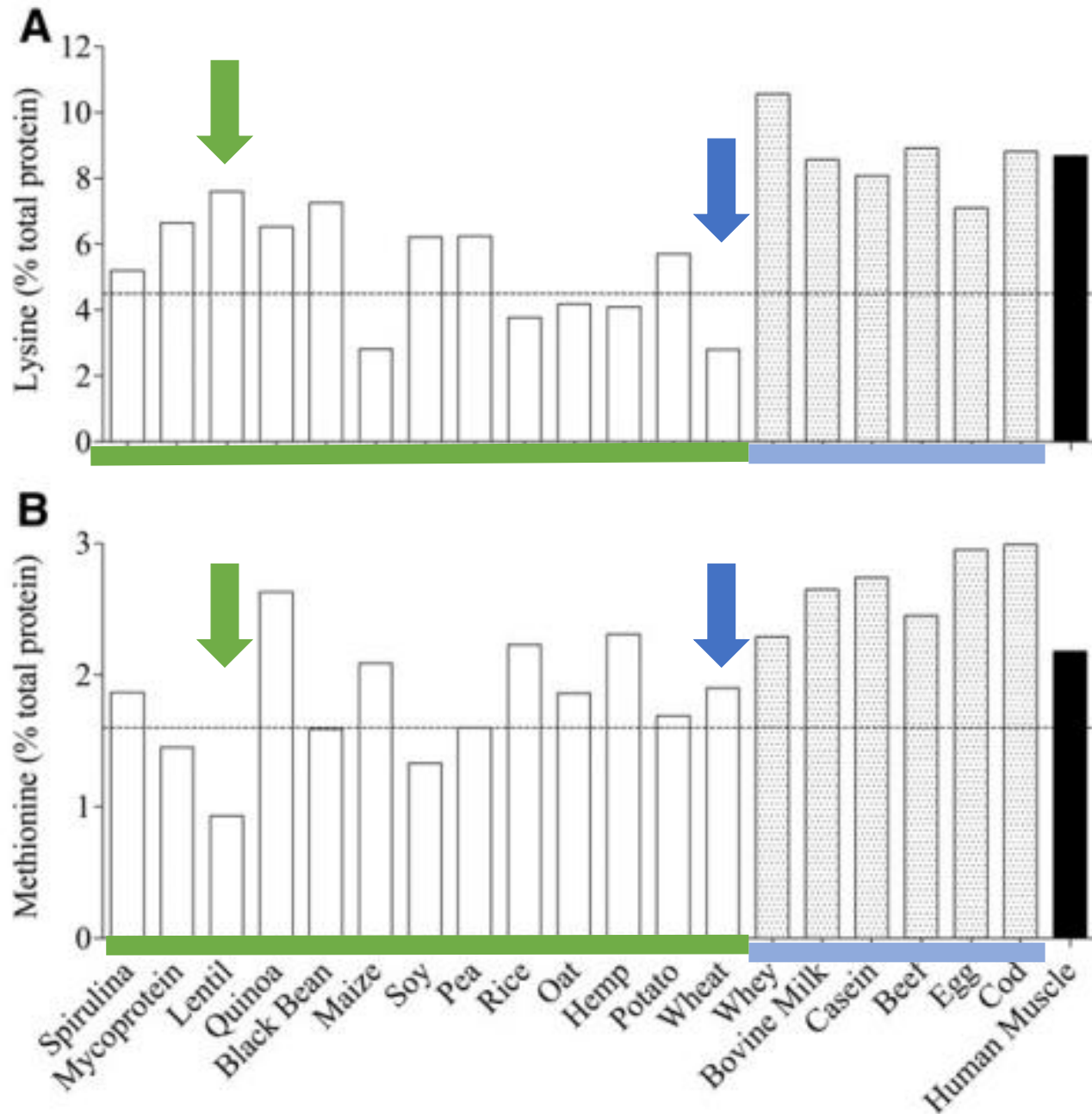
Gravide og ammende

Veganere



Protein Quantity and Quality



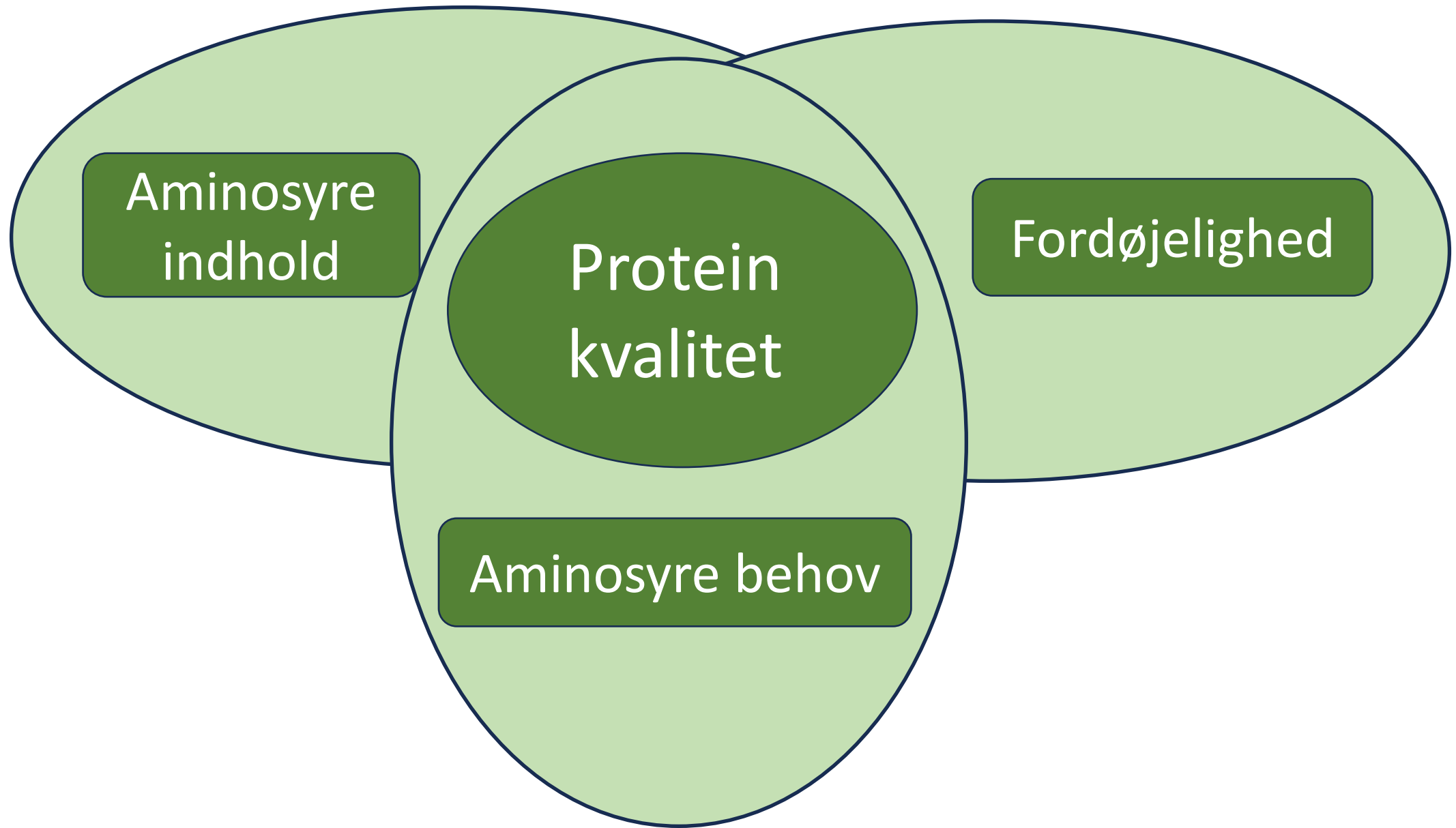


Lysine (A) and methionine (B) concentrations of various protein sources: Plant-based and Animal-based.

Human muscle is provided as the reference standard according to WHO/FAO/UNU

The dashed lines represent recommendations for a minimal intake by WHO/FAO/UNU

Vliet et al (2015). The skeletal muscle anabolic response to plant-versus animal-based protein consumption. JN 145:1981-91



Aminosyre
indhold

Protein
kvalitet

Fordøjelighed

Aminosyre behov

Proteinkvalitet – metoder til måling/beregning

- ❑ **Aminosyre score:** baseret på aminosyreindhold sammenlignet med et 'ideelt' protein
- ❑ **PDCAAS:** aminosyreindhold med korrektion for protein fordøjelighed og udtrykt i forhold til behov
- ❑ **DIAAS:** aminosyreindhold med korrektion for fordøjelighed i tyndtarmen af hver enkelt aminosyre og udtrykt i forhold til behov



Methods of Estimating Protein Quality.

D.M. Hegsted

It has long been known that proteins differ greatly in their nutritive value. This can be demonstrated grossly by any number of methods such as comparison of rates of growth, nitrogen retention, or other measures of physiological performance of animals or human subjects consuming different amounts of different proteins. It is also clear that these differences are in most instances related to the amino acid composition of the proteins since...

For a number of years (1,2,3) it has been assumed that some of these measures of nutritive value of proteins of differing quality were consumed if the requirement for one particular protein was a dietary protein that is maximally utilized. The appropriate values for other diets containing a dietary protein that is maximally utilized. For example, if the protein requirement for individuals of a certain size, age and sex is only 50% utilized, 4X when the dietary protein is only 25% utilized, etc.

This method of calculating protein requirements clearly requires that the measure of nutritive value be in the same fashion. Recent observations raise grave doubts as to the validity of these assumptions.

Biological Value (BV)

Biological value, as defined by Thomas (4) and Mitchell (5,6) has long been considered the best method of evaluating the nutritive value of absorbed nitrogen retained in the body* and a complete evaluation of the dietary protein requires measuring the fecal and urinary nitrogen when the test protein is fed and correcting for the nitrogen absorbed from the gut

Protein quality evaluation

Report of Joint FAO/WHO Expert Consultation

FAO
FOOD AND
NUTRITION
PAPER
51

Digestibility

Dietary protein quality evaluation in human nutrition

Report of an FAO Expert Consultation

ISSN 0254-4725

FAO
FOOD AND
NUTRITION
PAPER

92



1971: PER: Protein efficiency ratio
1991: PDCAAS: Protein digestibility corrected amino acid score in relation to Human Requirements
2013: DIAAS: Digestible Indispensable Amino Acid Score in relation to a Reference Protein

Protein kvalitet udtrykt som PDCAAS

	P:E ratio	Lysine (mg/g protein)	Threonine (mg/g protein)	SAA's (mg/g protein)	Tryptophan (mg/g protein)	Score	Limiting amino acid	Digestibility	PDCAAS	Adjusted P:E ratios
Requirement pattern		48	25	23	6.6					
Beef	0.66	91	47	40	13	100		100	100	0.660
Egg	0.34	70	47	57	17	100		100	100	0.340
Cow's milk	0.19	78	44	33	14	100		100	100	0.194
Breast milk	0.060	69	44	33	17	100		100	100	0.060
Soya	0.388	65	38	25	13	100		90	90	0.349
Wheat	0.160	26	29	45	12	54	Lysine	95	51	0.082
Maize	0.130	29	36	29	5	60	Lysine	82	50	0.064
Improved maize	0.135	40	44	48	7	83	Lysine	80	67	0.090
Potatoes	0.100	54	38	29	14	100		82	82	0.082
Rice	0.072	36	37	40	11	75	Lysine	82	62	0.044
Yam	0.061	42	34	28	13	88	Lysine	80	70	0.043
Cassava	0.034	32	21	29	14	67	Lysine	80	53	0.018

Animal foods generally perform well on both counts. Lysine is the limiting amino acid for cereal proteins, yam, and cassava. Maize also contains less than the reference tryptophan level, but at 83% of reference compared with lysine at 60%.

Proteinkvalitet udtrykt som **DIAAS**

Protein source	DIAAS	Limiting amino acid
<i>Cereals</i>		
Corn	38	Lysine
Rice	52	Lysine
Wheat	39	Lysine
Oat	44	Lysine
Barley	50	Lysine
<i>Legumes</i>		
Soy	92	Methionine + Cysteine
Fava bean	67	Methionine + Cysteine
Lupin	68	Methionine + Cysteine
Pea	66	Methionine + Cysteine
Chickpeas	69	Methionine + Cysteine
Lentils	75	Methionine + Cysteine
Kidney beans	61	Methionine + Cysteine
<i>Root vegetables</i>		
Potato	85	Histidine
<i>Animal proteins</i>		
Gelatin	2	Tryptophan
Whey	85	Histidine
Casein	117	None
Milk	108	None
Egg	101	None
Pork	117	None
Chicken	108	None
Beef	112	None

Proteinkvalitet – beregning i praksis

Fordøjeligheds-faktorer

NEVO product group	NEVO product group description	Overview of digestibility factors in literature per food group	Final digestibility factor
1	Potatoes and tubers	<ul style="list-style-type: none"> Potatoes: 0.55 (1) Sweet potatoes: 0.5 (1) Potatoes are more often consumed than sweet potatoes, therefore 0.55.	0.55
2	Alcoholic beverages	Plant-based products	0.65
3	Bread	0.9 (1)	0.9
4	Miscellaneous foods (plant-based foods such as seaweed, cacao powder, yeast, etc.)	<ul style="list-style-type: none"> Seaweed: 0.43 (2) Yeast: 0.82 (3) Cacao powder: 0.36 (4) Almonds (for almond paste): 0.88 (4) 	0.65
5	Eggs	0.97 (5, 6)	0.97
6	Fruits	<ul style="list-style-type: none"> Kiwi: 0.6 (1) Fruit 0.76 (7) 	0.76
7	Pastry and biscuits	<ul style="list-style-type: none"> Biscuits: 0.9 (1) Wheat flour biscuit: 0.9 (1) 	0.9
8	Cereals and cereal products	<ul style="list-style-type: none"> Barley: 0.78 (1) Breakfast cereal (1): Flaked corn 0.67 (1) Rollled oat 0.9 (1) Wheat bran 0.73 (1) Corn/corn flour: 0.82 (1) Oats: 0.74 (1, 4, 8) Rice: 0.9 (but cooked 0.7) (1), 0.88 (5) Whole wheat 0.45 (7) Wheat: 0.93 (1), 0.86 (5) Wheat flour: 0.9 (1) 	0.7
9	Vegetables	0.65 (5)	0.65
10	Savory bread spreads	<ul style="list-style-type: none"> Peanut butter 0.95 (6) Savory spread (vegetable spread): 0.65 (5) Savory spread is only a small part of the products in this group	0.9
11	Savory sauces	Animal-based: 0.9 Plant-based: 0.65	0.9
12	Savory snacks	<ul style="list-style-type: none"> Potato crisps: 0.47 (1) Potato fries: 0.50 (1) 	0.9
13	Cheese	0.95 (5, 6)	0.95
14	Herbs and spices	Plant-based products	0.65
15	Milk and milk products	Milk: 0.95 (1, 5)	0.95

PROTEIN AND AMINO ACID REQUIREMENTS IN HUMAN NUTRITION

Report of a Joint WHO/FAO/UNU Expert Consultation





Perspectives

Perspective: Developing a Nutrient-Based Framework for Protein Quality

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A B S T R A C T

The future of precision nutrition requires treating amino acids as essential nutrients. Currently, recognition of essential amino acid requirements is embedded within a generalized measure of protein quality known as the PDCAAS (Protein Digestibility-Corrected Amino Acid Score). Calculating the PDCAAS includes the FAO/WHO/UNU amino acid score, which is based on the limiting amino acid in a food, that is, the single amino acid with the lowest concentration compared to the reference standard. That “limiting” amino acid score is then multiplied by a bioavailability factor to obtain the PDCAAS, which ranks proteins from 0.0 (poor quality) to 1.0 (high quality). However, the PDCAAS has multiple limitations: it only allows for direct protein quality comparison between 2 proteins, and it is not scalable, transparent, or additive. We therefore propose that shifting the protein quality evaluation paradigm from the current generalized perspective to a precision nutrition focus treating amino acids as unique, metabolically active nutrients will be valuable for multiple areas of science and public health. We report the development and validation of the Essential Amino Acid 9 (EAA-9) score, an innovative, nutrient-based protein quality scoring framework. EAA-9 scores can be used to ensure that dietary recommendations for each essential amino acid are met. The EAA-9 scoring framework also offers the advantages of being additive and, perhaps most importantly, allows for personalization of essential amino acid needs based on age or metabolic conditions. Comparisons of the EAA-9 score with PDCAAS demonstrated the validity of the EAA-9 framework, and practical applications demonstrated that the EAA-9 framework is a powerful tool for precision nutrition applications.

Keywords: amino acids, protein quality, DIAAS, lysine, leucine, PDCAAS, dietary recommendations, precision nutrition

Introduction

Amino acids are unique nutrients with individual dietary requirements and distinct, noninterchangeable metabolic functions [1]. Just as vitamins A, B₆, C, and D have distinct functions and metabolic requirements despite being grouped as vitamins, amino acids are equally distinct despite being grouped as protein. Nevertheless, an understanding of amino acids as unique nutrients has not yet been clearly incorporated into nutrition recommendations or protein quality scores.

Most consumer-facing dietary guidelines still treat amino acids as interchangeable equivalents by generically representing them as “protein.” This generalization is built into nutrition recommendations such as the Dietary Guidelines for Americans (DGA) and the Nutrition Facts Panel, which both use protein as a

surrogate for amino acid requirements [2,3]. The DGA and Nutrition Facts Panel are informed by DRI reports, which specify the amounts of the 9 essential amino acids (EAAs) that must be consumed in the diet. However, DRI data is not intended for consumers and is not built in an easily accessible, user-friendly format for professionals’ use [4].

Currently, there is no available dietary guideline framework that evaluates food or meal protein quality based on the distinct metabolic roles and requirements of EAAs or that allows professionals or consumers to customize a diet based on specific individual requirements for one or more EAAs.

Understanding amino acids as individual nutrients requires understanding their unique metabolic roles beyond the fundamental role for protein synthesis (Table 1) [5–12]. For example, leucine (Leu) is a dietary signal that activates the mTOR

Abbreviations: AAS, amino acid score; DGA, Dietary Guidelines for Americans; DIAAS, Digestible Indispensable Amino Acid Score; EAA, essential amino acid; EAA-9, Essential Amino Acid 9; PDCAAS, Protein Digestibility-Corrected Amino Acid Score; SR Legacy, USDA National Nutrient Database for Standard Reference Legacy Release.

* Corresponding author. E-mail address: shavawn@nutrientinstitute.org (S.M. Forester).

<https://doi.org/10.1016/j.tjnut.2023.06.004>

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EAA-9 score

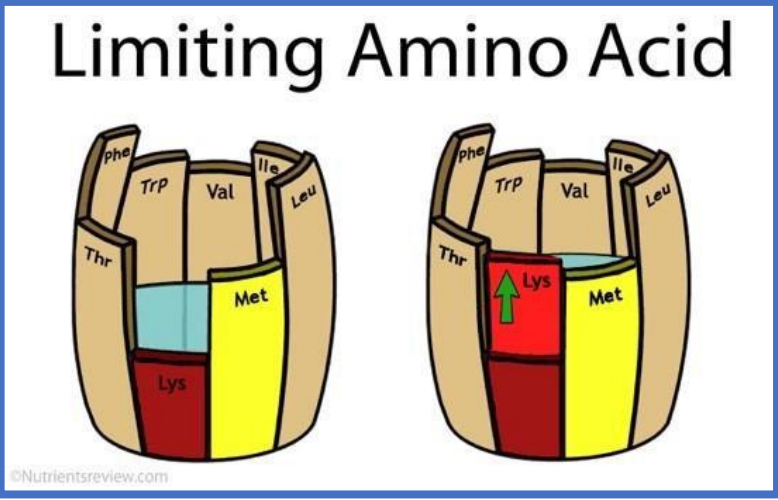
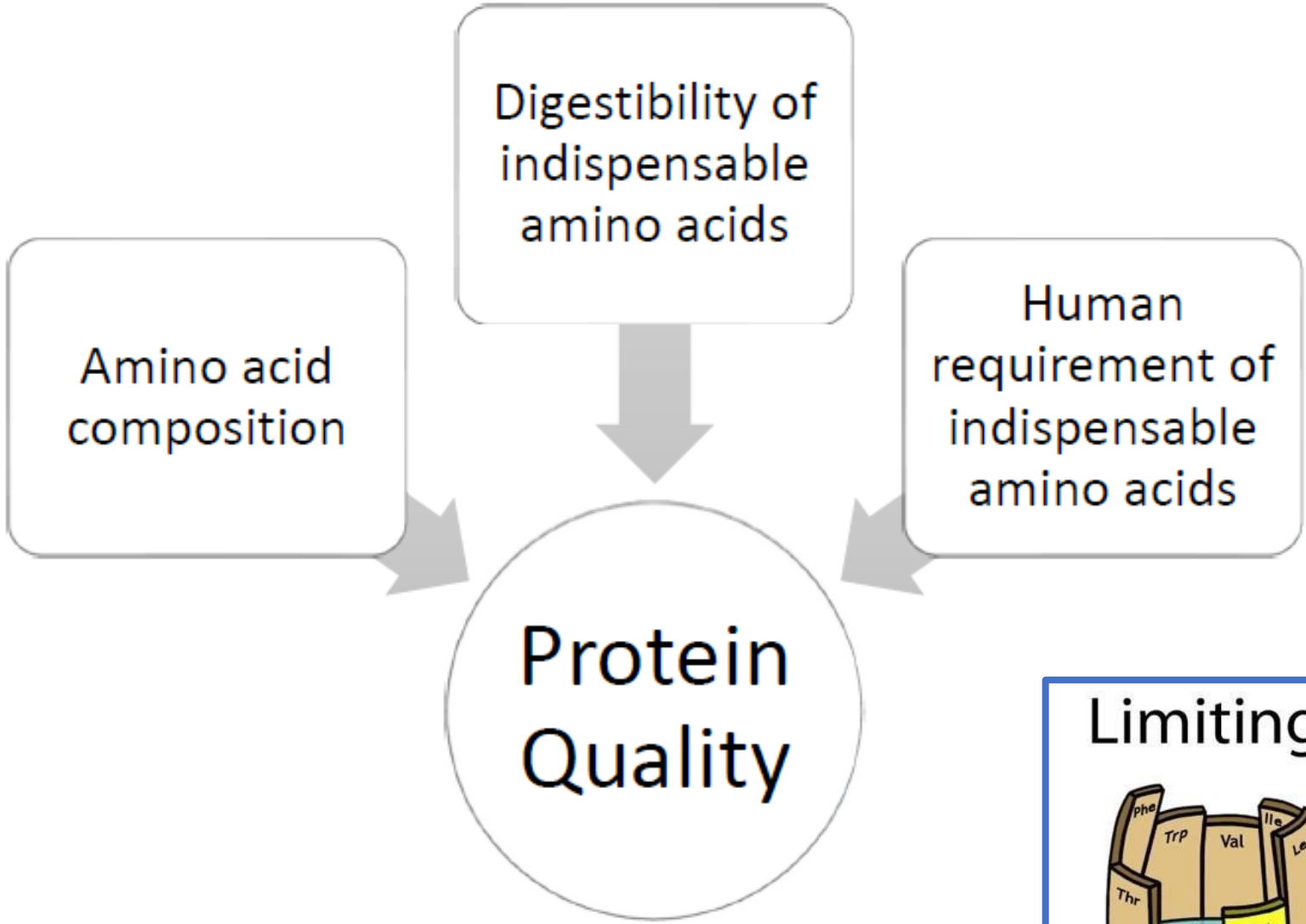
Et værktøj til at:

- beregne og sammenligne proteinkvalitet på tværs af ingredienser, fødevarer og måltider
- Beregne proteinkvalitet for en enkelte (personificeret)

Fordele fremhævet af forfattere:

- Additiv
- EAA-9 score repræsenterer % EAA-krav opfyldt
- Kan bruges på individ niveau

Forester SM (2023). *J.Nutrition*
doi:10.1016/j.tjnut.2023.06.004





MPQS

Måltids Proteinkvalitets Score



Behov for essentielle aminosyrer **per måltid:**

- Total protein: 0.3 g/kg BW
- Multiply by FAO/WHO behov
- Justering for fordøjelighed
- Laveste procent relativt til behov = **MPQS**

MPQS: 61
Limiting:
Methionine



- 125 kidney beans
- 150 bulgur
- 30 cherry tomatoes
- 20 olive oil
- 30 tofu
- 90 spinach

Opskrifter fra BBH: Meal Protein Quality Score

ONLY ENTER VALUES IN THE BLUE BOX



Torsdag menu 1 fisk med rejer



Dato 09-02-2024

Portions		20														
Grams	Ingredient	digestibility	isoleucine	leucine	lysine	methionine	cysteine	met + cys	phenylalanine	tyrosine	phe+tyr	threonine	tryptohan	valine	histidine	
301	Asparagus white boiled	0,65	0	0	0	0	0	0	0	0	0	0	0	0	0	
167	Beans broad boiled	0,65	209	303	331	80	23	103	149	114	263	226	60	269	103	
42	Celery boiled	0,65	0	0	0	0	0	0	0	0	0	0	0	0	0	
10	Cornstarch	0,7	0	0	0	0	0	0	0	0	0	0	0	0	0	
50	Cream 25% fat	0,95	83	137	128	36	11	47	72	60	132	60	19	99	41	
79	Drink soya natural	0,94	126	217	178	35	37	72	138	87	225	108	36	134	70	
43	Flour wheat white	0,7	140	286	94	64	90	154	204	118	322	112	49	170	89	
145	Peas chick boiled	0,75	370	619	566	106	119	225	477	238	715	317	66	370	225	
152	Egg whole chicken av boiled	0,97	1075	1656	1429	640	377	1017	1017	813	1830	871	256	1364	465	
143	Tahoe soya curd	0,94	708	1213	996	198	208	406	772	490	1261	602	200	748	394	
25	Chervil fresh	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
755	Tomatoes classic round raw	0,65	0	0	0	0	0	0	0	0	0	0	0	0	0	
3	Linseeds	0,75	21	29	20	9	8	17	23	12	34	18	7	25	11	
44	Flour rye	0,7	122	212	132	52	48	100	148	80	228	116	39	180	80	
13	Sunflower seeds	0,75	67	102	62	38	28	66	76	41	117	59	26	80	42	
1	Yeast fresh	0,65	4	6	6	1	0	1	3	3	6	4	1	5	2	
82	Flour rye	0,7	227	395	247	97	90	187	276	148	425	217	72	336	148	
14	Flour wheat white	0,7	45	93	31	21	29	50	66	38	105	37	16	55	29	
14	Syrup maple	0,8	0	0	0	0	0	0	0	0	0	0	0	0	0	
58	Peas chick boiled	0,75	149	250	229	43	48	91	193	96	289	128	27	149	91	
16	Flour rye	0,7	44	77	48	19	18	36	54	29	83	42	14	66	29	
246	Peas frozen boiled	0,65	460	691	644	106	33	138	398	276	675	415	83	584	200	
86	Peas chick boiled	0,75	220	368	336	63	71	133	284	141	425	188	39	220	133	
47	Pumpkin seeds	0,75	380	733	400	215	114	329	533	350	883	306	179	503	240	
451	Potatoes wo skin boiled av	0,55	177	259	276	66	40	106	191	92	283	160	73	283	85	
188	Radish raw	0,65	0	0	0	0	0	0	0	0	0	0	0	0	0	
39	Tempeh fermented soya beans prepared wo fat	0,94	203	348	286	57	60	116	221	140	362	173	57	214	113	
20	Buckwheat groats	0,7	46	83	73	21	12	33	52	27	79	44	21	69	29	
1000	Prawns cooked	0,9	7334	10857	11954	3991	930	4920	6006	5325	11331	5325	1553	7334	2882	
0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	total meal (mg)		12209	18931	18466	5956	2392	8348	11352	8719	20071	9527	2893	13256	5498	
	total meal (mg/person)		610	947	923	298	120	417	568	436	1004	476	145	663	275	
	percentage of requirement		93	73	94	85	91				121	95	110	78	84	

Meal Protein Quality Score
73

Limiting EAA:
Leucine



Opskrifter fra BBH: *Meal Protein Quality Score*

ONLY ENTER VALUES IN THE BLUE BOX



Torsdag menu 1 fisk –
rejer udskiftet med tun



Dato 09-02-2024

Portions		20																
Grams	Ingredient	digestibility	isoleucine	leucine	lysine	methionine	cysteine	met + cys	phenylalanine	tyrosine	phe+tyr	threonine	tryptohan	valine	histidine	Meal Protein Quality Score		
301	Asparagus white boiled	0,65	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
167	Beans broad boiled	0,65	209	303	331	80	23	103	149	114	263	226	60	269	103	110		
42	Celery boiled	0,65	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	Cornstarch	0,7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
50	Cream 25% fat	0,95	83	137	128	36	11	47	72	60	132	60	19	99	41	Limiting EAA:		
79	Drink soya natural	0,94	126	217	178	35	37	72	138	87	225	108	36	134	70			
43	Flour wheat white	0,7	140	286	94	64	90	154	204	118	322	112	49	170	89			
145	Peas chick boiled	0,75	370	619	566	106	119	225	477	238	715	317	66	370	225			
152	Egg whole chicken av boiled	0,97	1075	1656	1429	640	377	1017	1017	813	1830	871	256	1364	465			
143	Tahoe soya curd	0,94	708	1213	996	198	208	406	772	490	1261	602	200	748	394			
25	Chervil fresh	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
755	Tomatoes classic round raw	0,65	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	Linseeds	0,75	21	29	20	9	8	17	23	12	34	18	7	25	11			
44	Flour rye	0,7	122	212	132	52	48	100	148	80	228	116	39	180	80			
13	Sunflower seeds	0,75	67	102	62	38	28	66	76	41	117	59	26	80	42			
1	Yeast fresh	0,65	4	6	6	1	0	1	3	3	6	4	1	5	2			
82	Flour rye	0,7	227	395	247	97	90	187	276	148	425	217	72	336	148			
14	Flour wheat white	0,7	45	93	31	21	29	50	66	38	105	37	16	55	29			
14	Syrup maple	0,8	0	0	0	0	0	0	0	0	0	0	0	0	0			
58	Peas chick boiled	0,75	149	250	229	43	48	91	193	96	289	128	27	149	91			
16	Flour rye	0,7	44	77	48	19	18	36	54	29	83	42	14	66	29			
246	Peas frozen boiled	0,65	460	691	644	106	33	138	398	276	675	415	83	584	200			
86	Peas chick boiled	0,75	220	368	336	63	71	133	284	141	425	188	39	220	133			
47	Pumpkin seeds	0,75	380	733	400	215	114	329	533	350	883	306	179	503	240			
451	Potatoes wo skin boiled av	0,55	177	259	276	66	40	106	191	92	283	160	73	283	85			
188	Radish raw	0,65	0	0	0	0	0	0	0	0	0	0	0	0	0			
39	Tempeh fermented soya beans prepared wo fat	0,94	203	348	286	57	60	116	221	140	362	173	57	214	113			
20	Buckwheat groats	0,7	46	83	73	21	12	33	52	27	79	44	21	69	29			
1000	Tuna prepared wo fat	0,9	14219	20298	24613	7766	1853	9620	10787	9492	20279	11669	3020	15984	13336			
0		0	0	0	0	0	0	0	0	0	0	0	0	0	0			
	total meal (mg)		19094	28373	31125	9732	3315	13047	16132	12886	29019	15871	4359	21906	15952			
	total meal (mg/person)		955	1419	1556	487	166	652	807	644	1451	794	218	1095	798			
	percentage of requirement		45	110	158	139	126				174	158	166	128	243			



Original Research

Meal Protein Quality Score: A Novel Tool to Evaluate Protein Quantity and Quality of Meals



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A B S T R A C T

Background: The recent shift toward increased plant-based protein consumption has necessitated the development of new tools to evaluate the quality and quantity of protein in meals, especially given the changing dietary guidelines and the adoption of plant-centric menus in healthcare and other settings.

Objectives: To develop and test the feasibility of the meal protein quality score (MPQS), a novel metric that assesses the protein quality and quantity in meals based on essential amino acid (EAA) content, digestibility, and requirements, with a focus on optimizing protein intake for vulnerable populations, particularly older adults.

Methods: The MPQS integrates digestibility-adjusted EAA intake with total protein consumed in a meal, which, together with the EAA requirements, provides a score from 0 to 100 to reflect EAA coverage adequacy. The score was tested for feasibility by applying it to recipe data from real-life hospital meals and to dietary data from the [New Dietary Strategies Addressing the Specific Needs of Elderly Population for Healthy Aging in Europe] NU-AGE trial, involving detailed 7-d food records from 252 nonvegan participants analyzed over multiple meal moments.

Results: The analyses revealed that the higher the content of plant protein in a meal, the lower the meal protein quality. Also, breakfast meals scored lowest on protein quality, mainly due to low contents of protein overall, and of lysine and methionine. The MPQS effectively highlighted the difference in protein quality between plant-based and animal-based meals, and across different meal types.

Conclusions: The MPQS appears to be a practical tool that facilitates the assessment of meal-based protein quality. The MPQS can be used to guide dietary transitions toward plant-rich diets, ensuring that such shifts do not compromise protein adequacy for at-risk populations. The score allows for guidance in meal planning, leading to improvements in plant-rich meal formulation to meet both individual and public health nutritional needs.

Keywords: protein quality, meal protein quality score, plant-based proteins, plant-based diets, veganism.

Introduction

The shift in dietary protein intake toward more plant-based proteins instead of animal-based proteins is gaining traction among consumers, employees, hospital patients, and dietary guidelines [1]. Although the beneficial effects of this transition on cardiometabolic outcomes and environmental sustainability are much welcome, it does pose a health risk to some groups of

consumers [2]. These are, in general, consumers with increased protein requirements, lower food intakes, at risk of malnutrition, or at risk of sarcopenia, such as older adults and patients [3]. For these consumers, the lower anabolic properties of plant-based proteins, due to their reduced protein concentrations and quality, could increase risks of sarcopenia and osteoporosis [4].

Protein quality is a product of the digestibility, the essential amino acid (EAA) contents of a protein source, and the amino

Abbreviations: DIAAS, digestible indispensable amino acid score; EAA, essential amino acid; EAA-9, essential amino acid 9 score; MPQS, meal protein quality score; PDCAAS, protein digestibility-corrected amino acid score.

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Meal Protein Quality Score: A Novel Tool to Evaluate Protein Quantity and Quality of Meals

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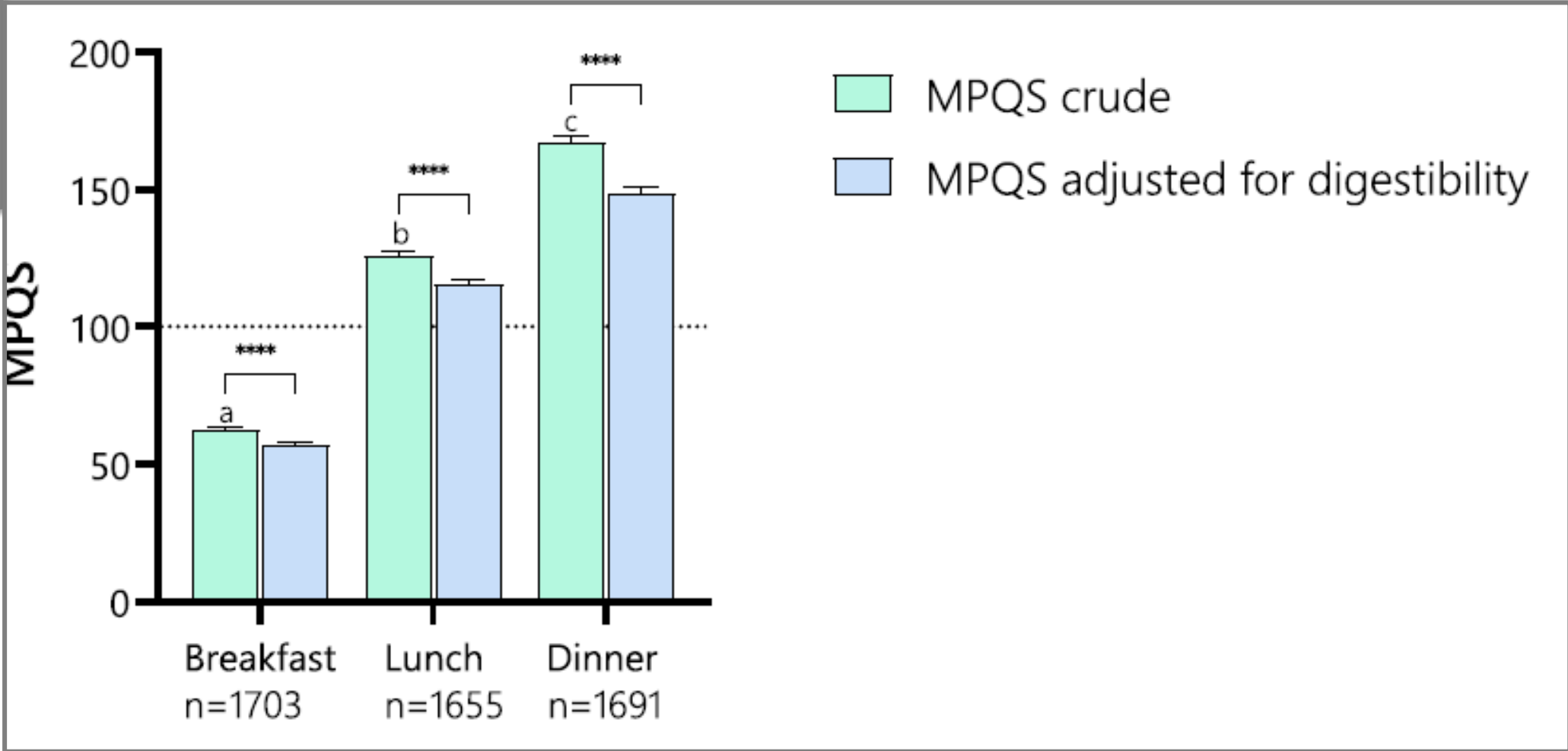
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Background: The recent shift toward increased plant-based protein consumption has necessitated the development of new tools to evaluate the quality and quantity of protein in meals, especially given the changing dietary guidelines and the adoption of plant-centric menus in healthcare and other settings.
Objective: To develop and test the feasibility of the meal protein quality score (MPQS), a novel metric that assesses the protein quality and quantity in meals based on essential amino acid (EAA) content, digestibility, and requirements, with a focus on optimizing protein intake for vulnerable populations, particularly older adults.
Methods: The MPQS integrates digestibility-adjusted EAA intake with total protein consumed in a meal, which, together with the EAA requirements, provides a score from 0 to 100 to reflect EAA coverage adequacy. The score was tested for feasibility by applying it to recipe data from meal-life hospital meals and to dietary data from the Dine Dietary Biobank. Addressing the Specific Needs of Elderly Population for Healthy Aging in Europe (INSAGE) trial, involving 74 food records from 282 nursing-home residents and over multiple meals.
Results: The analyses revealed that the higher the content of plant proteins in a meal, the lower the meal protein quality. Also, breakfast meals scored lower on protein quality, mostly due to low amounts of protein overall, and of lysine and methionine. The MPQS effectively highlighted the difference in protein quality between plant-based and animal-based meals, and across different meal types.
Conclusions: The MPQS appears to be a practical tool that facilitates the assessment of meal-based protein quality. The MPQS can be used to guide dietary transitions toward plant-rich diets, ensuring that such shifts do not compromise protein adequacy for at-risk populations. The score allows for guidance in meal planning, leading to improvements in plant-based meal formulations to meet both individual and public health nutritional needs.

Keywords: protein quality, meal protein quality score, plant-based proteins, plant-based diets, vegetarian.

Introduction
 The shift in dietary protein intake toward more plant-based protein instead of animal-based protein is gaining traction among consumers, employees, hospital patients, and dietary guidelines (1). Although the beneficial effects of this transition on cardiovascular outcomes and environmental sustainability are much welcome, it does pose a health risk to some groups of consumers (2). These are, in general, consumers with increased protein requirements (lower food intake, at risk of malnutrition, or at risk of sarcopenia, such as older adults and patients (3)). For these consumers, the lower analytic properties of plant-based protein, due to their reduced protein concentrations and quality, could increase risks of sarcopenia and osteoporosis (4). Protein quality is a product of the digestibility, the essential amino acid (EAA) contents of a protein source, and the amino

Abbreviations: DHAAs, digestible indispensable amino acid score; EAA, essential amino acid; EAAAs, essential amino acid; EAA score, meal protein quality score; PQAAs, protein digestible indispensable amino acid score.
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Take-home messages

- ✓ Proteinkvalitet er blevet et vigtigt emne i forhold til den grønne omstilling – især ift ældre, børn og veganere
- ✓ Flere metoder, som PDCAAS og DIAAS, bruges til at beregne proteinkvalitet, men der er ingen enighed om den bedste metode
- ✓ Nye værktøjer som EEA-9 og MPQS er udviklet til specifikke formål for at vurdere proteinkvalitet til specifikke formål

