Anabolic properties of meat consumption

Prof. L.J.C. van Loon

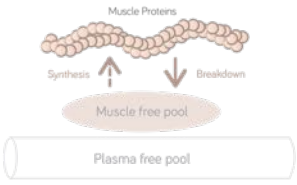


Maastricht University Medical Centre+
Maastricht, the Netherlands

Maastricht, October 11, 2023



Muscle protein turnover



Burd et al., *Exerc Sport Sci Rev*, 2013

Fractional muscle protein synthesis rates

1-2 % per day

(0.04 – 0.14 %·h^{-1})

Muscle reconditioning



Lance Armstrong



Jay Cutler

Muscle deconditioning



- immobilisation
- sarcopenia
- cancer cachexia
- COPD
- type 2 diabetes
- cardiovascular disease

Muscle maintenance

Main anabolic stimuli

Muscle contraction is an anabolic stimulus



Nutrition is an anabolic stimulus



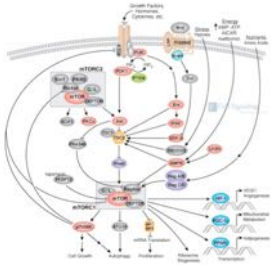
Amino acids







Amino acids stimulate protein synthesis



Post-prandial muscle protein synthesis

- protein digestion
- amino acid absorption
- plasma amino acid availability
- hormonal response
- postprandial perfusion
- muscle protein signaling proteins
- myofibrillar protein synthesis

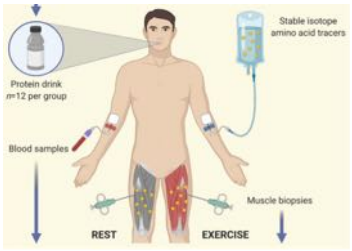


Research methods





Stable isotope tracer infusion



Trommelen *et al., Proc Nutr Soc*, 2021

Post-prandial muscle protein synthesis

- protein digestion
- amino acid absorption
- plasma amino acid availability
- hormonal response
- postprandial perfusion
- muscle protein signaling proteins
- myofibrillar protein synthesis



Stable isotope tracers




Intrinsically labeled protein



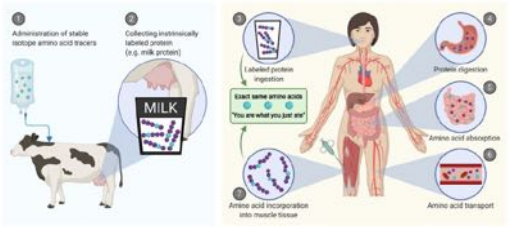
van Loon *et al., J Dairy Sci*, 2009, Pennings *et al., J Dairy Sci*, 2010, Burd *et al., PLOS One*, 2013

Clinical nutrition studies



Groen et al., *PLOS one, 2015*

Post-prandial protein handling



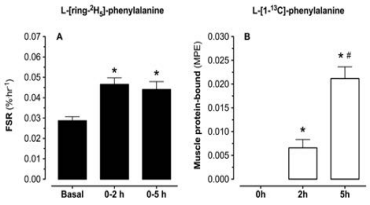
Trommelen et al., *Proc Nutr Soc*, 2021

Post-prandial protein synthesis



Groen et al., *PLOS one, 2015*

Post-prandial protein synthesis



Groen et al., *PLOS one, 2015*

'You are what you just ate'

Post-prandial protein synthesis


- source of protein


- amount of protein


- macronutrients


- timing


- food preparation


- body position

Source of protein



Amount of dietary protein



Other macronutrients



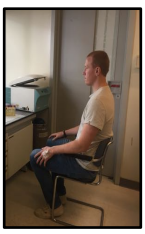
Timing of protein ingestion



Food preparation

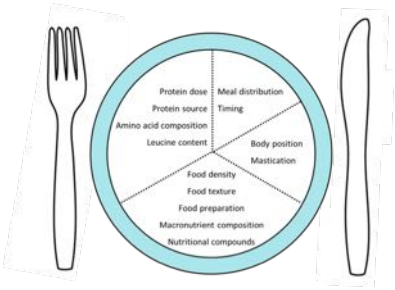


Body position





Post-prandial protein synthesis



Kouw et al., PhD thesis, 2018.

Post-prandial protein synthesis

 - source of protein

 - amount of protein

 - macronutrients

 - timing

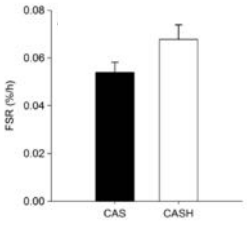
 - food preparation

 - body position

Source of protein

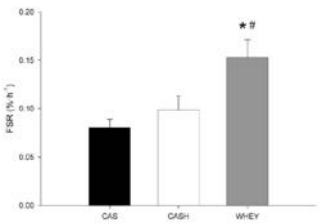


Intact protein versus protein hydrolysate



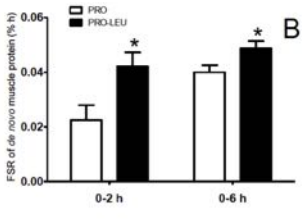
Koopman *et al., Am J Clin Nutr*, 2009

Whey versus casein



Pennings *et al., Am J Clin Nutr*, 2011

Leucine co-ingestion



Wall *et al., Clin Nutr*, 2013

Whey versus casein



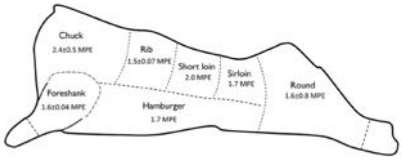
Milk versus Beef





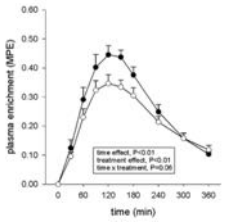
Burd *et al., Am J Clin Nutr, 2015*

Intrinsically labeled meat



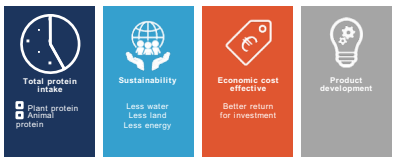
Burd *et al., Plos One*, 2013

Food matrix



Pennings *et al., Am J Clin Nutr*, 2014

Plant-based proteins



Plant-derived proteins: game changers?



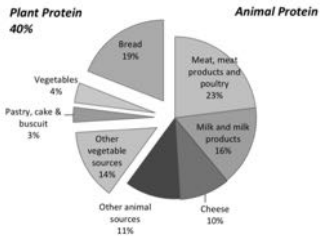
Plant based protein consumption

TABLE 1 Energy and protein consumption per capita per day[1]

	Energy intake, kJ/d	Energy intake, kcal/d	Total protein intake, g/d	Animal protein intake, % total protein intake	Plant protein intake, % total protein intake
Worldwide	10.6	2542	78	42	58
Region					
Africa	10.7	2560	67	23	77
Asia	11.3	2706	75	34	66
Americas	13.4	3205	92	56	44
Europe	14.1	3362	102	57	43
Oceania	13.9	3312	98	63	37
Economic class[2]					
Low income	10.0	2393	63	21	79
Low-middle income	10.9	2597	68	34	66
High-middle income	12.1	2907	83	46	54
High income	13.7	3296	101	58	42

van Vliet et al., J Nutr, 2015

Plant-based protein consumption



Tieland et al., Nutrients, 2015

Plant-based proteins

The Skeletal Muscle Anabolic Response to Plant- versus Animal-Based Protein Consumption[1]

Stephan van Vliet,[2,3] Nicholas A Burd,[2,3] and Luc JC van Loon[3]*

[2]Department of Kinesiology and Community Health, University of Illinois at Urbana-Champaign, Urbana, IL; and [3]Department of Human Movement Sciences, Faculty of Health, Medicine, and Life Sciences, School for Nutrition and Translational Research in Metabolism (NUTRIM), Maastricht University, Maastricht, Netherlands

van Vliet et al., J Nutr, 2015

Plant based proteins



van Vliet et al., J Nutr, 2015

Muscle gain on plant based protein consumption



Muscle gain on plant-based protein consumption



Bill Pearl - 1971

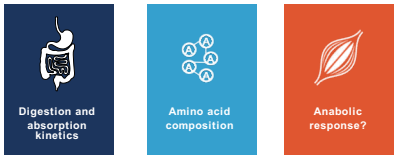
Protein quality

Protein quality scoring systems

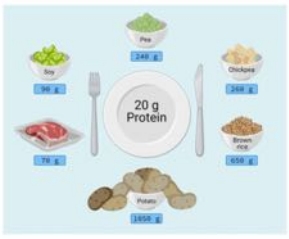
Food	PDCAAS	DIAAS
MPC[a]	1.00	1.18
WPI[a]	1.00	1.09
SPI[a]	0.98	0.90
PPC[a]	0.89	0.82
RPC[a]	0.42	0.37
Whole milk[b]	1.00	1.14
Chicken breast[b]	1.00	1.08
Egg (hard boiled)[b]	1.00	1.13
Cooked peas[a]	0.60	0.58
Cooked rice[a]	0.62	0.59
Almonds[b]	0.39	0.40
Chickpeas[b]	0.74	0.83
Tofu[b]	0.56	0.52
Corn-based cereal[b]	0.08	0.01
Hydrolyzed collagen[c]	0.0	0.0

Phillips, Frontiers Nutr, 2017

Protein derived amino acid availability

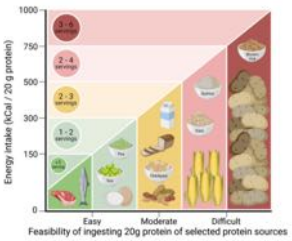


Plant-based whole-foods



Pinckaers et al., Sports Med, 2021

Plant-based versus animal-based whole-foods



Pinckaers et al., Sports Med, 2021

Plant derived protein isolates and concentrates



Soy-derived protein



Tang et al., *J Appl Physiol, 2009*
Yang et al., *Nutr Metab, 2012*

Wheat-derived protein



Gorissen et al., *J Nutr, 2016*

Plant derived proteins



- Essential amino acid content
- Leucine
- Methionine
- Lysine

van Vliet *et al., J Nutr,* 2015

ORIGINAL ARTICLE

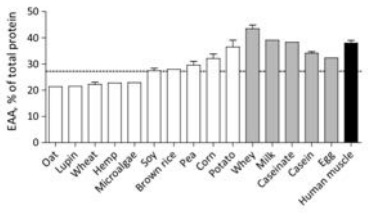
CrossMark

Protein content and amino acid composition of commercially available plant-based protein isolates

Stefan H. M. Gorissen[1] · Julie J. R. Crombag[1] · Joan M. G. Senden[1] · W. A. Huub Waterval[2] · Jörgen Bierau[2] · Lex B. Verdijk[1] · Luc J. C. van Loon[1]

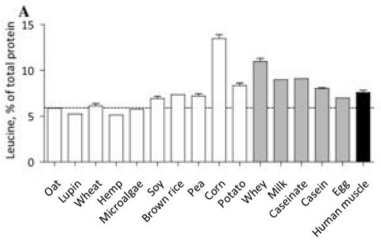
Gorissen et al., *Amino Acids, 2019*

Essential amino acid content



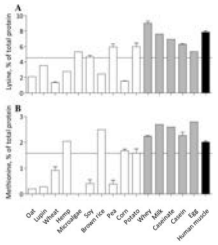
Gorissen et al., *Amino Acids, 2019*

Leucine content



Gorissen et al., Amino Acids, 2019

Amino acid deficiencies



Gorissen et al., Amino Acids, 2019

Wheat-derived protein

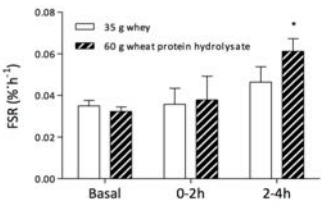


Gorissen et al. J Nutr, 2016

Plant- and animal-derived protein sources

Source	Leucine (%)	Protein per meal
Plant derived protein sources		
Corn	12.2	28
Rice	8.2	43
Soy	8.0	44
Pea	7.8	44
Oat	7.7	45
Quinoa	7.2	49
Wheat	6.8	51
Potato	6.0	58
Animal derived protein sources		
Whey	13.6	25
Bovine Milk	10.9	32
Casein	10.2	34
Beef	8.8	39
Egg	8.5	41
Cod	8.1	43

Dose response effect



Gorissen et al., J. Nutr, 2016

Amount of protein

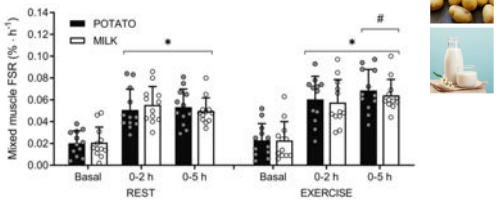


Plant-derived protein isolates and concentrates



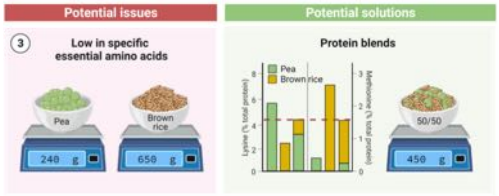
Pinckaers et al., *Brit J Nutr*, 2021
Pinckaers et al., *J Nutr*, 2022
Pinckaers et al., *Med Sci Sport Exerc*, 2022
Pinckaers et al., unpublished work

Anabolic properties of potato-derived protein



Pinckaers et al., *Med Sci Sports Exerc*, 2022

Anabolic properties of plant-based proteins



Pinckaers et al., *Sports Med*, 2021

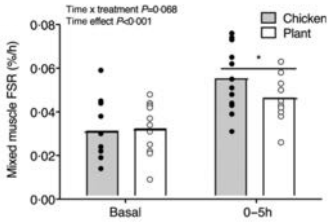
Meat alternatives

Plant-based meat alternatives



Kouw et al., *Brit J Nutr*, 2021

Plant-based meat alternatives



Kouw et al., *Brit J Nutr*, 2021

Research warranted

Whole-foods and food processing

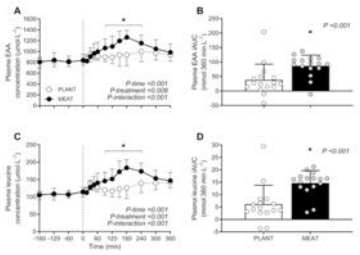


Vegan versus omnivorous meal



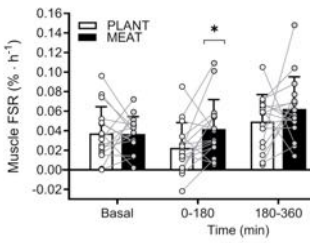
Pinckaers et al., unpublished

Vegan versus omnivorous meal



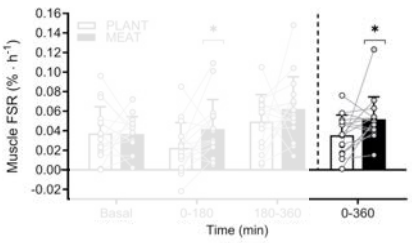
Pinckaers et al., unpublished

Vegan versus omnivorous meal



Pinckaers et al., unpublished

Vegan versus omnivorous meal



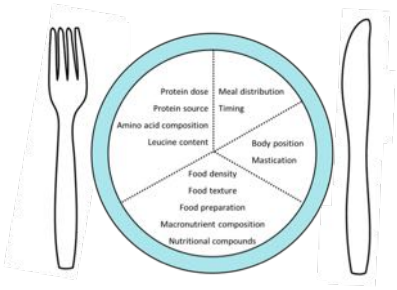
Pinckaers et al., unpublished

Longer term impact of dietary modulation

Beef as a key component of a diet that stimulates muscle protein synthesis



Post-prandial protein synthesis



Kouw et al., PhD thesis, 2018.

Conclusions I

Both animal and plant-derived protein consumption increase muscle protein synthesis rates

Some plant-derived proteins show a lesser muscle protein synthetic response when compared to animal-derived proteins

To maximize the anabolic properties of plant-derived proteins you can increase the amount of protein consumed, combine different protein sources, and/or fortify with amino acids

Conclusions II

Consumption of a whole-foods meal containing beef increases muscle protein synthesis rates to a greater extend when compared to the ingestion of an isonitrogenous and isocaloric whole-foods plant-based meal.

Collaborators and sponsors


The M3 Research Group specialised in muscle metabolism
WWW.M3-RESEARCH.NL