The anabolic action of the food matrix and its implications for athletes

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In *Sports Nutrition seminar*
Dairy Council of Northern Ireland
Nov 10, 2021

T.K. Cureton Physical Fitness Research Lab

Outline

I. Eating amino acids stimulates muscle protein synthesis, so does exercise.

II. Food focused approaches in the development of 'optimal' protein recommendations

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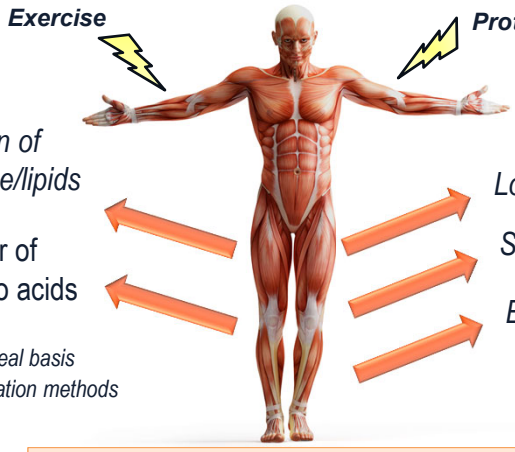
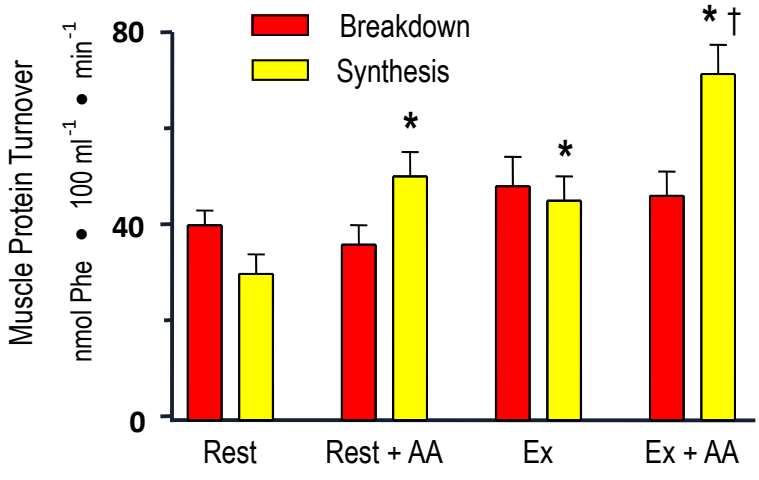
Muscle focused approach to protein requirements (and quality as opposed to DIAAS)



*provide on a per meal basis
*use direct incorporation methods

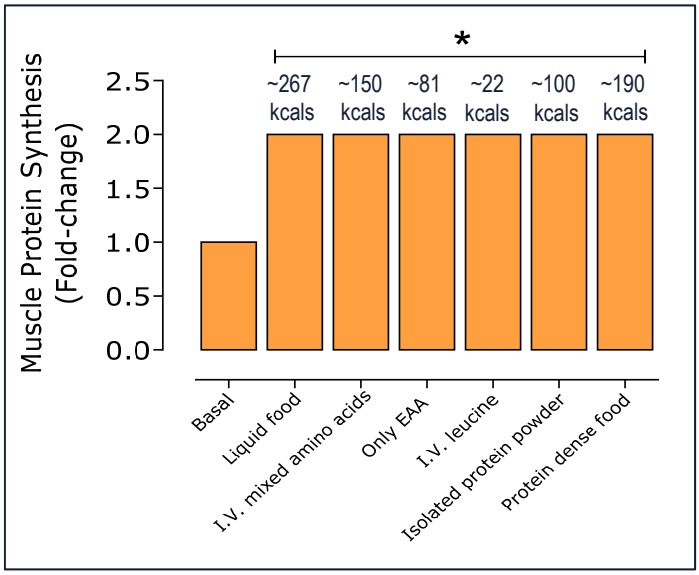
↑↑ hypertrophic and non-hypertrophic muscle protein remodeling

Free amino acids and exercise



Biolo et al. Am. J. Physiol. '95
Biolo et al. Am. J. Physiol. '97

Amino acids stimulate muscle protein synthesis



Rennie MJ, Millward DJ *et al.* (1982) Clin Sci

Carroll CC, Trappe TA et al. (2005) AJP

Volpi E, Wolfe RR *et al.* (2003) AJCN

Smith K, Rennie MJ *et al.* (1992) AJP

Tang J, Phillips SM *et al.* (2009) JAP

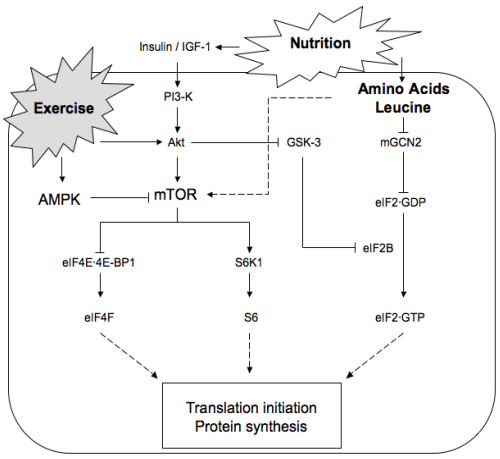
Beals JW, Burd NA *et al.* (2016) AJCN

May and Hill (1990) AJCN

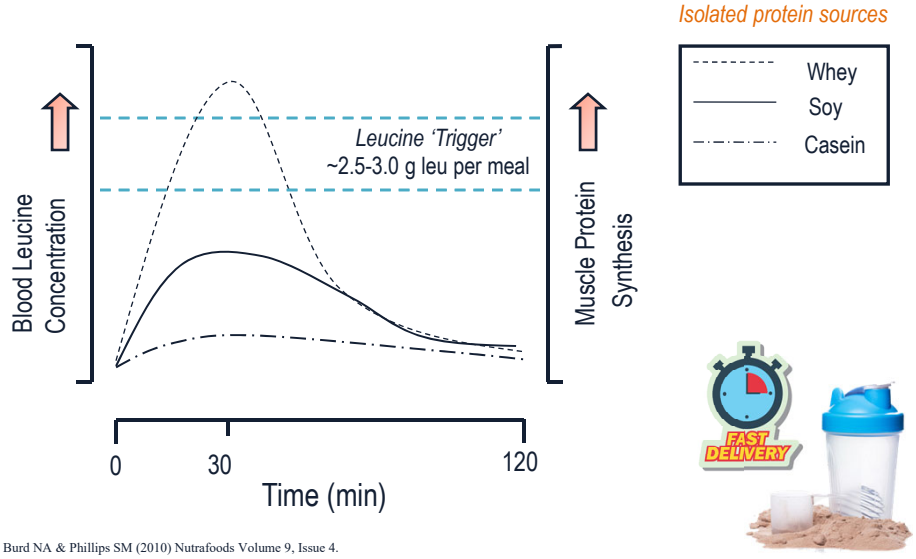
**MPS responses truncated at 2-fold to highlight the potent anabolic action of ea. condition*

Amino acids and the pursuit of dietary leucine

Leucine as a main anabolic signal



'Fast' isolated proteins and the pursuit of dietary leucine



Burd NA & Phillips SM (2010) Nutrafoods Volume 9, Issue 4.

Common characteristics of a protein source to **maximize** the anabolic potential of the muscle adaptive response

- Amino acid composition that mirrors that of human body protein to prevent AA antagonism
- Higher leucine content
- 'Fast' speed of digestion and absorption
- ↑ dietary amino acid availability in circulation
- ↔ energy load/insulinemia
- ↑ muscle AA uptake
- ↑ signaling proteins in muscle tissue
- ↑ muscle protein synthesis

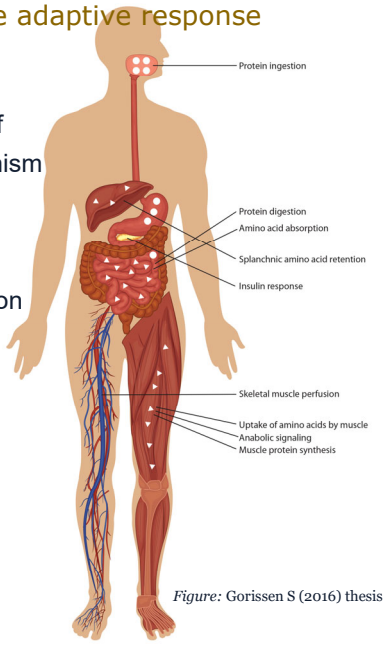
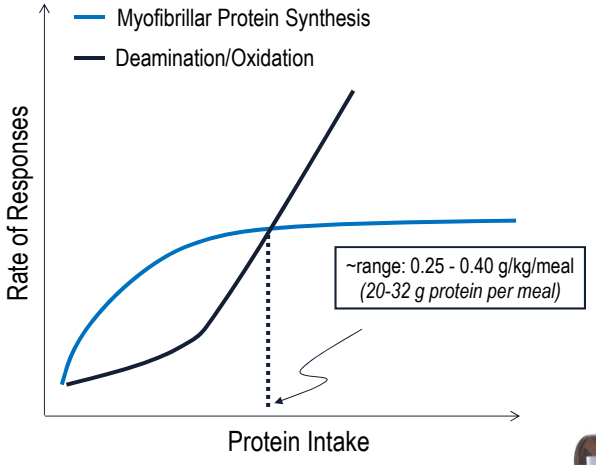


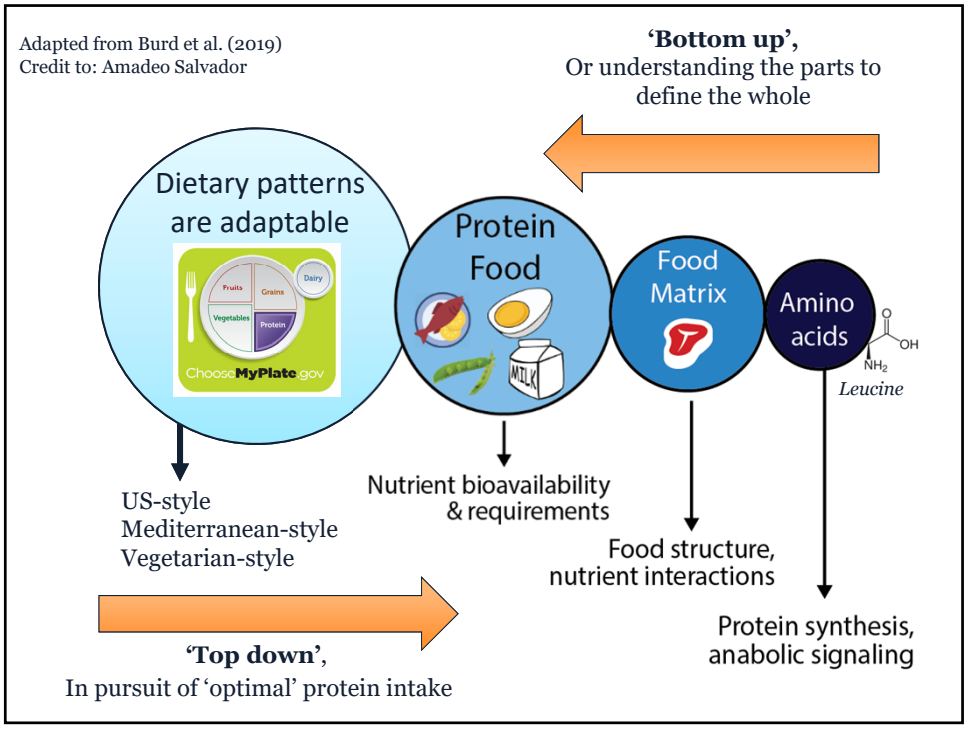
Figure: Gorissen S (2016) thesis

Single nutrient (protein) requirement to maximize MPS

Maximal Dosing in Response to isolated animal proteins



Morton RW, Phillips SM *et al.* (2018) Br J Sports Med
Moore DR *et al.* (2015) J Gerontol A Biol Sci Med
Moore DR *et al.* (2009) AJCN



What about exercise—how does this impact protein requirement?

Cycling

Parasport

Running

Weight lifting

Weight lifting is inherently anabolic

↑Whole body nitrogen retention

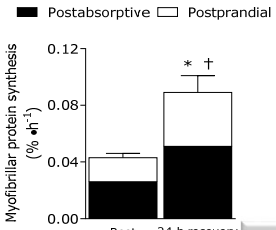
TABLE 1 Characteristics of young men before (pre) and after (post) a 12-wk whole body resistance training program[1]

	Pre	Post
Body mass, *kg*	78.5 ± 10.5	80.6 ± 9.9*
Lean body mass, *kg*	61.9 ± 6.9	64.8 ± 6.7*
Fat mass, *kg*	13.6 ± 5.0	12.8 ± 4.1*
Body fat, %	17.1 ± 4.4	15.7 ± 3.8*
Bone mineral content, *kg*	2.9 ± 0.4	3.0 ± 0.5

[1] Values are means ± SD, $n = 12$. * Different from pretraining, $P < 0.05$.

Moore DR, Phillips SM *et al.* (2007) J Nutr

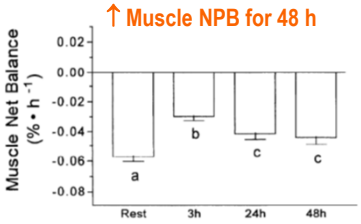
↑AA sensitivity of muscles



Burd, Phillips SM *et al.* (2012) J Nutr

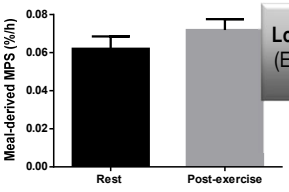
↑High protein intakes (2.2 g protein per kg)

↑ Muscle NPB for 48 h



Phillips SM *et al.* (1997) AJP

↑ 'Sink' for dietary AA



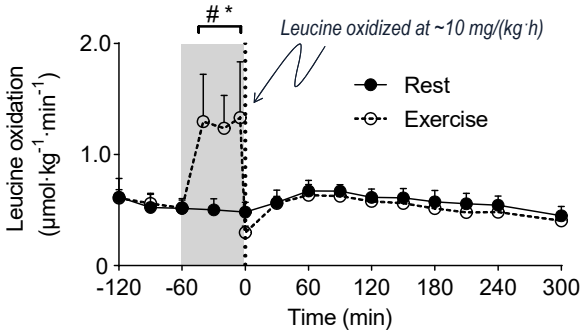
Pennings B, van Loon *et al.* (2011) AJCN

Low carbohydrate intake (Extra 0.12 g protein/kg/d)

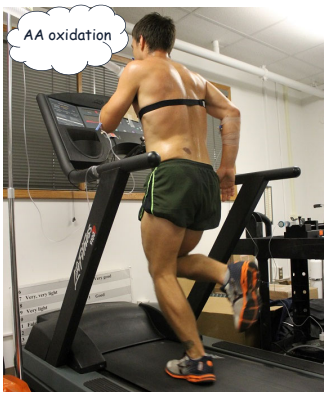
Endurance exercise and leucine oxidation

1 hour at 70% VO_2peak

Mixed meal (~0.25 g protein/kg)



Data are means ± SD
# denotes difference from baseline in exercise ($P < 0.01$)
* denotes difference between rest and exercise ($P < 0.01$)



Mazzulla et al. (2017) MSSE

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Protein intake—probably different based on routine activity, and is consistent with nutrition periodization concepts

~15 g/meal | ~20 g/meal | 20-30 g/meals | >30 g/meals?

Protein nutrition fits on a continuum


Sedentary, healthy


Strength


Endurance (1-2 h)


Prolonged Endurance (>2-3 h)

Exercise mode, intensity, and duration plays a role in the amount of protein that athletes likely need to consume post-exercise

*Estimated meal amounts based on 80 kg athlete

*Endurance athletes may need more in a single bolus or more frequent feeding during post-exercise recovery

The American Journal of Clinical Nutrition

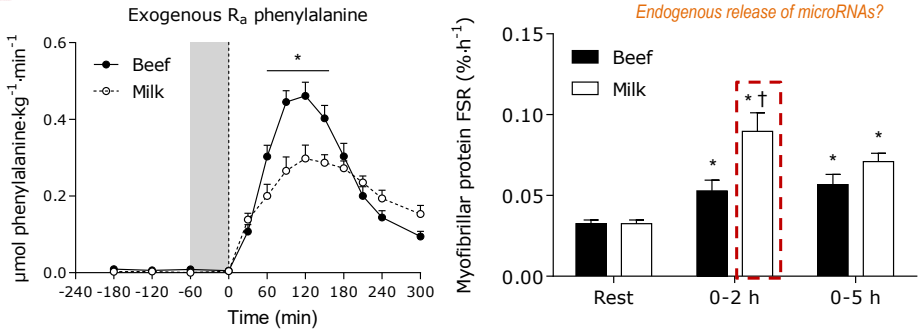
Differences in postprandial protein handling after beef compared with milk ingestion during postexercise recovery: a randomized controlled trial[1,2]

*Nicholas A Burd,[3] Stefan H Gorissen,[3] Stephan van Vliet, Tim Snijders, and Luc JC van Loon**

NUTRIM School of Nutrition and Translational Research in Metabolism, Maastricht University, Maastricht, Netherlands

Milk borne bioactive peptides?

Endogenous release of microRNAs?



Time × treatment interaction, $P = 0.006$; time effect, $P < 0.001$; treatment effect, $P = 0.055$.
*Significantly different compared with rest. †Significantly different between treatments..

Maastricht University

Am J Clin Nutr 2015;102:828-836

Milk Ingestion Stimulates Net Muscle Protein Synthesis following Resistance Exercise

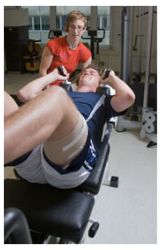
TABATHA A. ELLIOT, MELANIE G. CREE, ARTHUR P. SANFORD, ROBERT R. WOLFE, and KEVIN D. TIPTON

Metabolism Unit, Shriners Hospitals for Children and Department of Surgery, The University of Texas Medical Branch, Galveston, TX

TABLE 2. Nutrient content of the milk consumed by each group following resistance exercise.

	Energy (kJ)	CHO (g)	Fat (g)	Protein (g)	Phenylalanine (mg)	Threonine (mg)
FM	377	12.3	0.6	8.8	420	390
WM	627	11.4	8.2	8.0	390	360
IM	626	20.4	1.0	14.5	696	647

FM, 237 g of fat-free milk; WM, 237 g of whole milk; IM, 393 g of fat-free milk; CHO, carbohydrate.



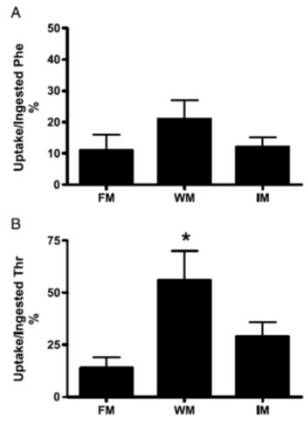


FIGURE 5—Ratio of the amino acid uptake relative to the amount ingested for phenylalanine (A) and threonine (B) following ingestion of milk during recovery from resistance exercise. Groups as in Figure 1.

Modulation of the anabolic action of isolated protein with isolated food components?

- **Addition of carbohydrate?**
  - 20 g casein *vs.* 20 g casein + 60 g carbohydrate
- **Addition of fat?**
  - 20 g casein *vs.* 20 g casein + 26.7 g milk fat
- **Addition of milk serum?**
  - 25 g casein vs. 25 g casein + milk serum (10% lactose, 0.3% protein, 0.06% fat, ~1.1% minerals)

Gorissen SH, van Loon LJ et al. (2014) J Clin. Endocrinol Metab

Gorissen SH, van Loon LJ et al. (2015) Clin Nutr.

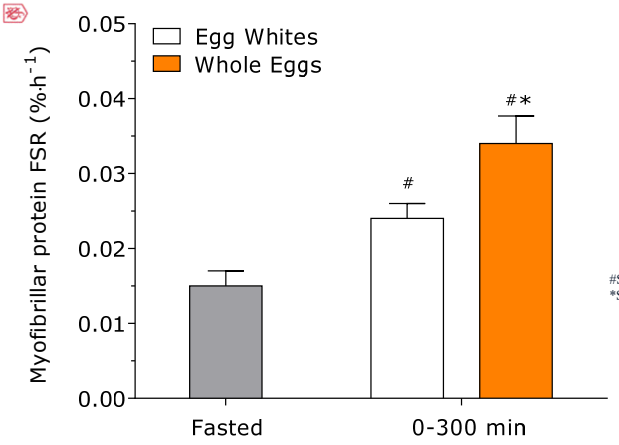
Churchward-venne TA, van Loon LJ et al. (2015) J Nutr

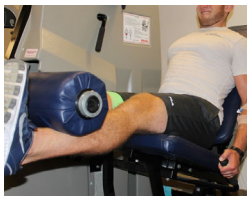
The American Journal of Clinical Nutrition

Consumption of whole eggs promotes greater stimulation of postexercise muscle protein synthesis than consumption of isonitrogenous amounts of egg whites in young men

Stephan van Vliet,[1] Evan L Shy,[1] Sidney Abou Sawan,[6] Joseph W Beals,[4] Daniel WD West,[6] Sarah K Skinner,[1] Alexander V Ulanov,[5] Zhong Li,[5] Scott A Paluska,[2] Carl M Parsons,[3] Daniel R Moore,[6] and Nicholas A Burd[1,4]

Departments of [1]Kinesiology and Community Health, [2]Family Medicine, and [3]Animal Sciences; [4]Division of Nutritional Sciences; and [5]Roy J Carver Biotechnology Center, University of Illinois at Urbana-Champaign, Urbana, IL; and [6]Faculty of Kinesiology and Physical Education, University of Toronto, Toronto, Ontario, Canada





#Significantly different from fasted (P<0.05).
*Significantly different between egg conditions (P<0.05).

Van Vliet S (2017) AJCN

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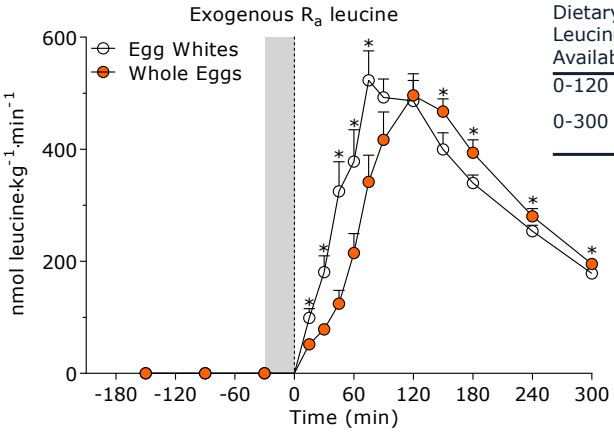
Postprandial release of dietary leucine



*Significantly different between egg conditions (P<0.05).
Gray area: exercise bout; Dashed line: egg ingestion.

Dietary Leucine Availability	Egg Whites (%)	Whole Eggs (%)	P-value
0-120 min	34±2*	25±3	0.02
0-300 min	68±1	66±2	0.70

Van Vliet S (2017) AJCN

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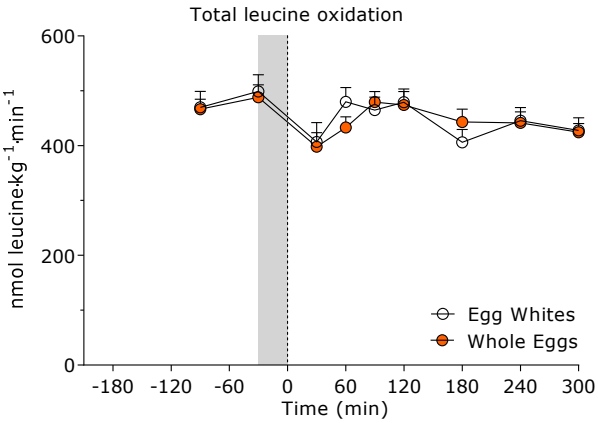
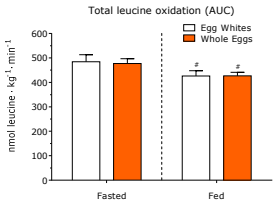
Whole body leucine oxidation rates



Total Ox: Time effect, P<0.001; Time × condition, P=0.386.
Total Ox AUC: Time effect, P<0.001; Time × condition P=0.739.
[#]Significantly different from fasted (P<0.05).
Gray area: exercise bout; Dashed line: egg ingestion.



Van Vliet S (2017) AJCN

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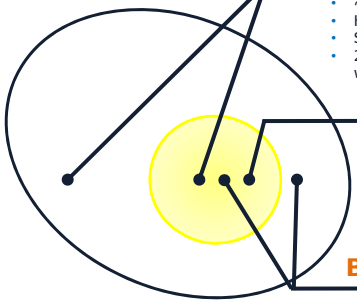
Food matrix effects?



PROTEIN

- ~5g protein per egg
- High biological value protein
- Stimulates skeletal MPS rates
- 20g of protein may maximally stimulate MPS without excess AA oxidation

LIPIDS

- ~4g fat per egg
- Cholesterol may stimulate mTORC1, thus influencing MPS
- Dietary cholesterol does not negatively impact blood cholesterol profiles
- Phospholipids with antioxidative function

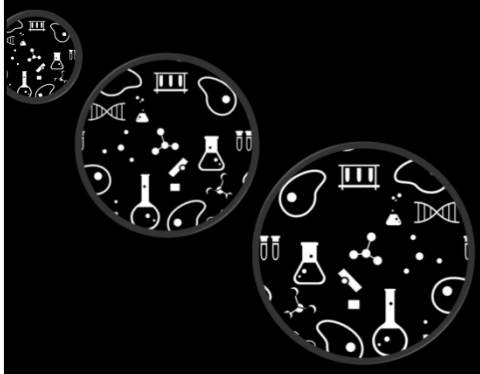
BIOACTIVE COMPOUNDS

- Choline for acetylcholine synthesis and cell membrane integrity
- Antioxidants (Vitamins A, E; Selenium)
- Peptide efficacy in humans remains unclear

The ***food matrix*** describes the overall physical form of food, and includes how various food components are structured and their interactions.

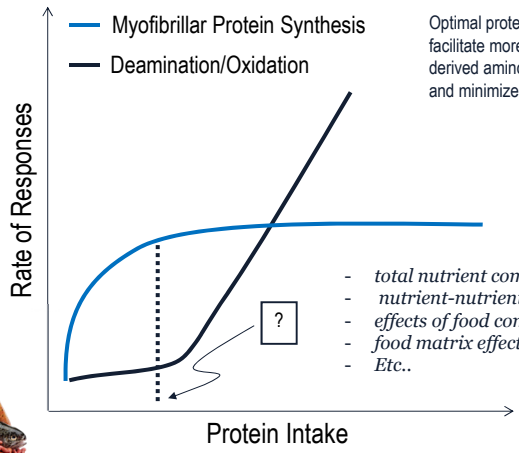
Credit to: Colleen McKenna

Do food components (amino acids) behave differently in isolated form than when forming part of food structures?



Leverage food matrix effects and exercise to optimize MPS?

Optimal Dosing?



Optimal protein dosing ranges strive to facilitate more efficient use of dietary protein derived amino acids for post-exercise MPS and minimize amino acid oxidation rates.

Common characteristics of a protein source to maximize the anabolic potential of the muscle adaptive response

- Amino acid composition that mirrors that of human body protein to prevent AA antagonism
- ↑ dietary amino acid availability in circulation
- ↔ energy load/insulinemia
- ↑ muscle AA uptake
- ↑ signaling proteins in muscle tissue
- ↑ muscle protein synthesis

↑↑Food matrix effects?

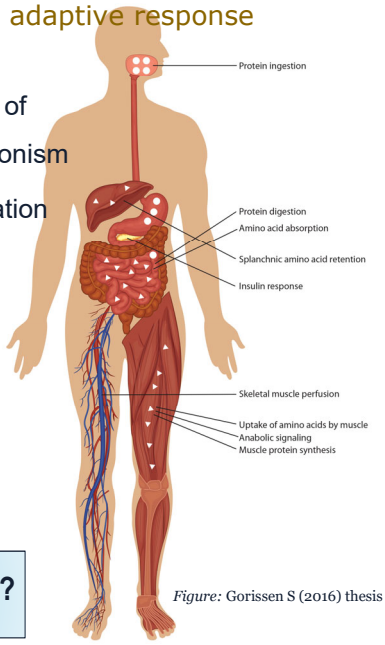
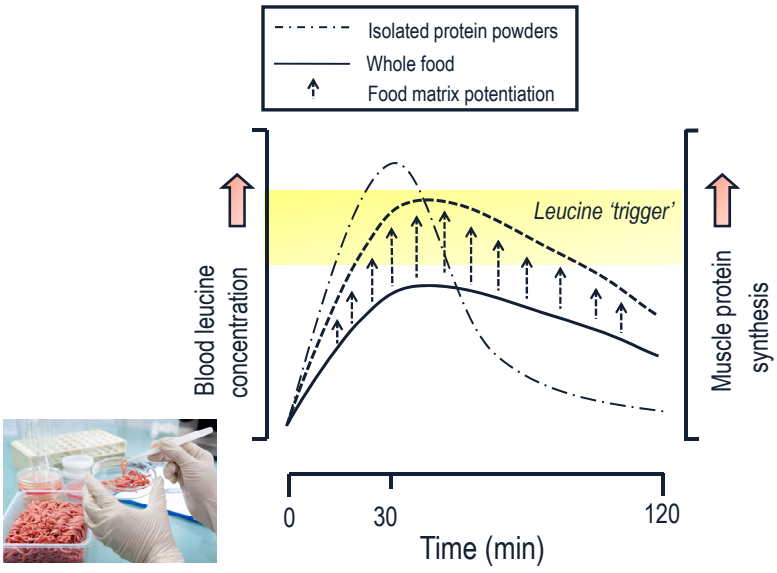


Figure: Gorissen S (2016) thesis

Food first approach to protein intake



Burd et al. (2019) Sports Medicine

Current Developments in Nutrition CDN

Curr Dev Nutr. 2020 Jun; 4(Suppl 2): 650.
Published online 2020 May 29. doi: 10.1093/cdn/nzaa049_043

PMCID: PMC7259043

Effects of Salmon Ingestion on Post-Exercise Muscle Protein Synthesis: Exploration of Whole Protein Foods Versus Isolated Nutrients

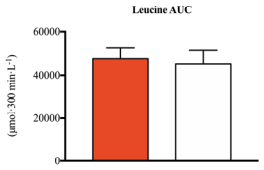
Kevin Paulussen,[1] Amadeo Salvador,[1] Colleen McKenna,[1] Susannah Scaroni,[1] Alexander Ulanov,[1] Zhong Li,[1] Daniel Moore,[2] Scott Paluska,[1] Ryan Dilger,[1] Laura Bauer,[1] and Nicholas Burd[1]

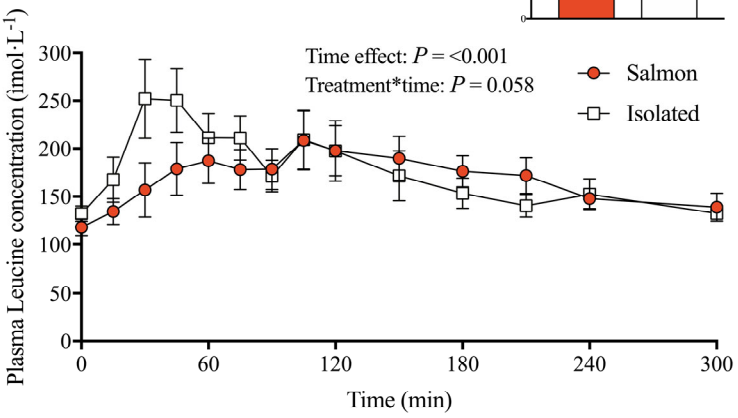
- **10 healthy men and women** (24±4 y; 5 M, 5 F)
- **Prime constant infusion**
- **Acute bout of resistance exercise**
- **Post-exercise treatment ingestion**

3.5 oz Salmon (~150 kcals)
20.5 g protein (1.7 g leucine)
7.6 g fat (~0.4 g EPA/~0.6 DHA)

Isolated mixture (~150 kcals)
20.5 g protein (1.7 g leucine)
7.6 g fat (~0.4 g EPA/~0.6 DHA + coconut oil)

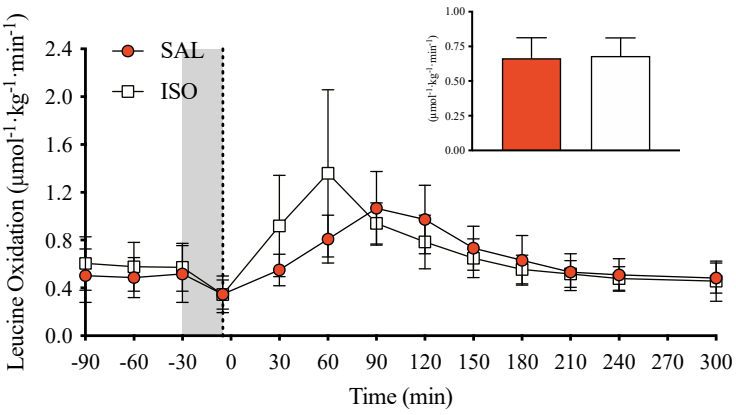
Whole foods vs. single nutrients: leucinemia





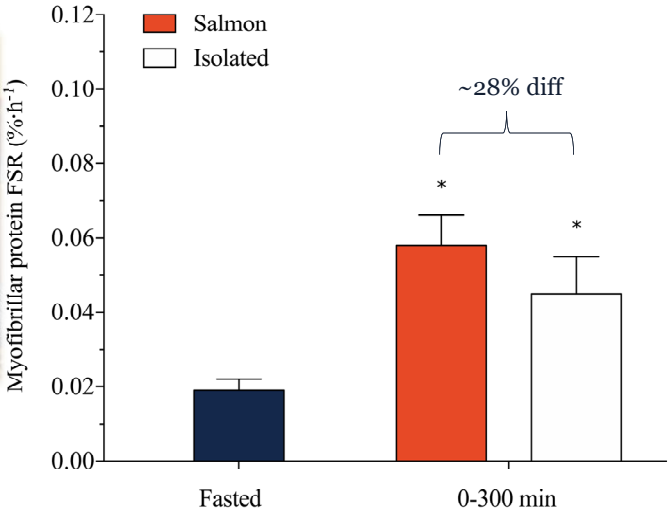
Paulussen K *et al.* (2020)

Whole foods vs. single nutrients: Leucine oxidation



Time effect: $P < 0.001$

Whole foods vs. single nutrients: Muscle protein synthesis



*significantly different from rest

Mean ± SD

Paulussen K *et al.* (2020)

Putting it together: Optimization strategies of dietary protein intake?

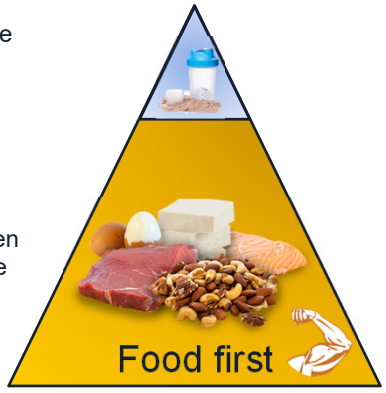
- ***Quality of life:*** Exercise mode, intensity, duration
- ***Dietary pattern:*** Timing and distribution of protein ingestion
- ***Protein Food:*** More than the sum of its amino acids

'Top down approach'

Identification of 'optimal' protein recommendations

'Optimal' protein intakes: food is the foundation

- Protein and nutrient dense foods should serve as the foundation of an 'optimal' anabolic feeding strategy and should help balance the need to pursue excessive protein targets
- Isolated protein foods are convenient to achieve absolute protein targets (and are often useful to help with protein distribution) but are not necessary to support exercise-induced muscle adaptations



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