R&D Forum

Protein

Chair: Suzane Leser, Vice-Chair, European Specialist Sports Nutrition Alliance (ESSNA), UK

Sponsored by:
Welcome

Delegate Questionnaire: Please complete and hand in at the end of the session

Networking Drinks Reception: Join us for drinks tonight, 18.00 in Central Restaurant (by the entrance to Hall 3)

Presentations: All presentations will be sent out post-event to the email addresses provided

Social media: Continue the conversation at #VFE17

Vitafoods Insights: visit vitafoodsisights.com - the online destination that delivers the best content from the Vitafoods events.
Increasing bioavailability in protein

Speaker: Dr. Jurriaan Mes, Senior Scientist Food Quality & Health Effects, Wageningen Food & Biobased Research, Netherlands
Bioavailability of Proteins

Vitafood May 10th 2017

Jurriaan Mes
Dietary proteins are major important

- Substrates for messenger RNA (mRNA) translation
- Protein synthesis in skeletal muscle and other tissues
- Cell-specific production of low-molecular-weight metabolites with enormous physiological importance
- Initiators of signal transduction and neurotransmission
- Biosynthesis of other nitrogen-containing compounds
  - such as glutathione, creatine, taurine, carnitine, nitric oxide, serotonin, and thyroxin
- Formation of nonnitrogenous compounds for gluconeogenesis, one-carbon methyl reactions, and anaplerotic balance of the tricarboxylic acid cycle
- Protein undernutrition results in stunting, anaemia, oedema, vascular dysfunction, impaired immunity among others
Global protein challenge ahead

840M people
Don’t have enough to eat today

1+ Billion
People without fresh water in 2050

60% increase
Of meat consumption till 2050

25% of world’s
Children suffer from malnutrition

18% of all GHG
Emissions come from livestock farming

70% of world’s
Arable land is used for livestock farming

GLOBAL DEMAND FOR MEAT
2005 vs. 2050

WAGENINGEN UNIVERSITY & RESEARCH
What proteins will we eat?
Important requirements for protein sources

- Safety, no adverse effect (anti-nutritional factors)
- Tasty and technological functionality
- Nutritious, providing EAA in good balance
- Societally accepted production (fair, organic, ecological footprint, sustainability, animal welfare etc.)
Recommended Dietary Allowance

- Healthy adult with minimal activity 0.8-1g prot/kg BW/d.
  - 1.3, and 1.6 g for moderate, and intense physical activity
- In general consumption of 2g/kg BW/d is safe for healthy adults
- Chronic intake >2 g/kg BW/day may result in digestive, renal, and vascular abnormalities and should be avoided

The quality of protein are the determinants of its nutritional values.

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Protein EAR (g·kg⁻¹·day⁻¹)</th>
<th>Protein RDA (g·kg⁻¹·day⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 through 6 mo (6 kg)</td>
<td>—</td>
<td>1.52 (AI)</td>
</tr>
<tr>
<td>6 through 12 mo (9 kg)</td>
<td>1.0</td>
<td>1.2</td>
</tr>
<tr>
<td>1 through 3 yr (12 kg)</td>
<td>0.88</td>
<td>1.10</td>
</tr>
<tr>
<td>4 through 8 yr (20 kg)</td>
<td>0.76</td>
<td>0.95</td>
</tr>
<tr>
<td>9 through 13 yr (36 kg)</td>
<td>0.76</td>
<td>0.95</td>
</tr>
<tr>
<td>14 through 18 yr</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Boys (61 kg)</td>
<td>0.73</td>
<td>0.85</td>
</tr>
<tr>
<td>Girls (54 kg)</td>
<td>0.71</td>
<td>0.85</td>
</tr>
<tr>
<td>≥19 yr</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Men (70 kg)</td>
<td>0.66</td>
<td>0.80</td>
</tr>
<tr>
<td>Women (57 kg)</td>
<td>0.66</td>
<td>0.80</td>
</tr>
<tr>
<td>Pregnant women</td>
<td>0.88</td>
<td>1.1</td>
</tr>
<tr>
<td>Lactating women</td>
<td>1.05</td>
<td>1.3</td>
</tr>
</tbody>
</table>
Protein ≠ Protein

- Bolus/amount
- Digestive system
- Microbiota
- Amino acid and peptide transport
- Intracellular peptidases
- Basolateral transporters
- Endocrine hormone that respond
- Influence of food matrix
- etc.
Interrelationships between intake and utilisation

Protein in Diet → Stomach and SI Proteases → Large Peptides

SI → Peptidases → Small Peptides (2 or 3 AA residues)

Dipeptidases → Tripeptidases → Enterocytes and Luminal Bacteria → Undegraded AA

AA → Transport → Large Intestine → (H₂S, SO₂, CO₂, CH₄, NH₄⁺, SCFA, AA, and microbial protein)

Undigested → Feces

25-95% Catabolism → Oxidation

NH₄⁺, Urea, Creatinine, Nitrate, and Other NM → Urine

AA → Metabolism in Liver and Extrahepatic Tissues

Wu, Food Funct., 2016, 7, 1251-1265
Bioactivity of peptides e.g.

- Enhance Ca, Fe, Zn absorption
- Reduce cholesterol absorption
- Bile acid binding capacity
- Suppress triglyceride absorption
- Antibacterial activity
- ACE inhibitor
- Opioid agonist or antagonist
- Anti-thrombotic activity
- Reduce permeability gut by increasing CLDN
- Induce permeability (lectin, agglutinate, gliadins)
- DPP4 inhibitor
- Induce number of goblet cells and/or mucus secretion (e.g. β-casomorphin-7)
- Increase IgA levels (Immunomodulation)
- Modulate gastric emptying and transit time
# Classification of Amino Acids

<table>
<thead>
<tr>
<th>Essential</th>
<th>Ess-precursor</th>
<th>Non-essential</th>
<th>Semi-essential</th>
</tr>
</thead>
<tbody>
<tr>
<td>histidine</td>
<td></td>
<td>alanine</td>
<td></td>
</tr>
<tr>
<td>isoleucine</td>
<td></td>
<td>aspartic acid</td>
<td>asparagin</td>
</tr>
<tr>
<td>leucine</td>
<td></td>
<td>glutamic acid</td>
<td>glutamine</td>
</tr>
<tr>
<td>lysine</td>
<td></td>
<td></td>
<td>arginine</td>
</tr>
<tr>
<td>methionine</td>
<td>cysteine</td>
<td></td>
<td>glycine</td>
</tr>
<tr>
<td>phenylalanine</td>
<td>tyrosine</td>
<td></td>
<td>proline</td>
</tr>
<tr>
<td>threonine</td>
<td></td>
<td></td>
<td>serine</td>
</tr>
<tr>
<td>tryptophan</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>valine</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Bioactivity of specific AA some e.g.

- **Glutamine** – precursor (arginine, purine nucleotides, pyrimidine nucleotides and glucosamine), metabolic fuel intestinal cells, proliferation, differentiation, repair intestinal cells, regulation TJ, restore plasma inflammatory cytokines, reduce E.coli infection

- **Tryptophan** – precursor (serotonin, vit B3), activate detoxification, regulating immune cells, expression TJ protein ZO-1

- **Leucine** - 2- to 3-fold increase in plasma or intracellular leucine concentrations for maximum activation of mTORC1 and stimulation of muscle protein synthesis

Essential / Indispensable amino acids

- Advised requirements have increased (will further ?)
- Need to match intake, eat more when one of AA is limited
- Make right balance between sources
- How can we take personal requirements into account
How to analyse dietary protein quality

- Traditional way “Protein Digestibility Corrected Amino Acid Score” - PDCAAS.

- Not properly
  - Use of Faecal Digestibility (rat assay)
  - Truncation of scores greater than 1.0 to 1.0 (loss of information)
  - Protein digestibility rather than individual amino acid digestibility
  - Use of conventional lysine (often first-limiting amino acid, is in error)
  - Inadequate representation of endogenous/metabolic protein
DIAAS better but enough?

- New score Digestible Indispensable Amino Acid Score:
  - Ileal digestibility of each amino acid (corrected for endogenous losses)
  - Available versus conventional digestible lysine
  - Disbanding Truncation of Scores
  - Pig as preferred animal model for determining digestibility
  - Updated reference (AA requirement) patterns
### Some examples PDCAAS/DIAAS

<table>
<thead>
<tr>
<th></th>
<th>Soya Protein Isolate</th>
<th>Pea Protein</th>
<th>Cooked Beans</th>
<th>Cooked Rolled Oats</th>
<th>Wheat Bran</th>
<th>Roasted Peanuts</th>
<th>Rice Protein</th>
<th>Cooked Peas</th>
</tr>
</thead>
<tbody>
<tr>
<td>PDCAAS</td>
<td>1.00</td>
<td>0.89</td>
<td>0.65</td>
<td>0.67</td>
<td>0.53</td>
<td>0.51</td>
<td>0.42</td>
<td>0.60</td>
</tr>
<tr>
<td>DIAAS</td>
<td>0.97</td>
<td>0.82</td>
<td>0.58</td>
<td>0.54</td>
<td>0.41</td>
<td>0.43</td>
<td>0.37</td>
<td>0.58</td>
</tr>
</tbody>
</table>

- **Proteos**
  - An initiative funded by the world’s food sectors (coordinated by Global Dairy Platform, GDP)
  - To provide a global dataset of true ileal AA digestibility and DIAAS (initially 100 foods)
How to analyse protein quality

- Problems:
  - Ignore physiological needs of EAA for tissue (e.g., skeletal muscle) protein synthesis or function
  - Roles of synthesizable AA in human nutrition and metabolism
  - Personal variation in digestion, uptake/transporters and specific AA requirements
  - Dynamics of AA availability
Circulating AA as dietary quality measurement

- The amount of circulating AA proportionally reflects the dietary protein quality
- ‘Fast’ and ‘slow’ proteins (Whey, casein resp)
- Form of protein (hydrolysate faster and easier taken up)

At the same time it takes into account
- Stomach emptying of liquid or fast form
- Personal digestive system
- Personal AA transporters
- Large amount AA already absorbed and utilized by intestine cells and immune cells lining up the intestine
- Regulation/dependency on incretins
- Interaction with other food compounds (e.g. carbohydrates)
- Physical activity before, during or several hours after intake
- Age

Need to understand this better to understand protein quality and currently this information is lacking

Rapeseed protein

Rapeseed (canola)
- Originally high content of anti-nutritive compounds like erucic acid, phytases and glucosinolates
- Limit digestion and therefore nutritional value
- Breeding and processing can optimise sources

Fleddermann et al 2013
- Canola protein isolate
- Canola protein hydrolysate
- Soy protein isolate

<table>
<thead>
<tr>
<th></th>
<th>PDCAAS</th>
<th>First limiting AA (1-2y)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Canola protein isolate</td>
<td>0.86</td>
<td>lysine</td>
</tr>
<tr>
<td>Canola protein hydrolysate</td>
<td>1.00</td>
<td>lysine</td>
</tr>
<tr>
<td>Soy protein isolate</td>
<td>0.84</td>
<td>Methionine and cysteine</td>
</tr>
</tbody>
</table>
Rapeseed

- 4% less CPI AUC (?)
- 13% less peak (*)

- 4% more AUC of CPH compare SPI
- 8% higher peak

Fleddermann et al 2013
# Potato protein

<table>
<thead>
<tr>
<th>Amino acid</th>
<th>HMW</th>
<th>LMW</th>
<th>Whey</th>
<th>Casein</th>
<th>Soy</th>
<th>Pea</th>
</tr>
</thead>
<tbody>
<tr>
<td>Isoleucine</td>
<td>39</td>
<td>45</td>
<td>55</td>
<td>58</td>
<td>48</td>
<td>45</td>
</tr>
<tr>
<td>Leucine</td>
<td>97</td>
<td>88</td>
<td>122</td>
<td>101</td>
<td>80</td>
<td>84</td>
</tr>
<tr>
<td>Lysine</td>
<td>67</td>
<td>65</td>
<td>112</td>
<td>83</td>
<td>63</td>
<td>72</td>
</tr>
<tr>
<td>Methionine (Met)</td>
<td>25</td>
<td>13</td>
<td>23</td>
<td>30</td>
<td>14</td>
<td>*</td>
</tr>
<tr>
<td>Cysteine (Cys)</td>
<td>7</td>
<td>23</td>
<td>30</td>
<td>4</td>
<td>12</td>
<td>*</td>
</tr>
<tr>
<td>Phenylalanine (Phe)</td>
<td>55</td>
<td>59</td>
<td>36</td>
<td>54</td>
<td>52</td>
<td>**</td>
</tr>
<tr>
<td>Tyrosine (Tyr)</td>
<td>55</td>
<td>52</td>
<td>37</td>
<td>58</td>
<td>38</td>
<td>**</td>
</tr>
<tr>
<td>Threonine</td>
<td>66</td>
<td>44</td>
<td>45</td>
<td>46</td>
<td>37</td>
<td>39</td>
</tr>
<tr>
<td>Tryptophan</td>
<td>10</td>
<td>14</td>
<td>27</td>
<td>14</td>
<td>11</td>
<td>10</td>
</tr>
<tr>
<td>Valine</td>
<td>44</td>
<td>65</td>
<td>52</td>
<td>74</td>
<td>48</td>
<td>50</td>
</tr>
<tr>
<td>Histidine</td>
<td>18</td>
<td>14</td>
<td>22</td>
<td>32</td>
<td>25</td>
<td>25</td>
</tr>
</tbody>
</table>

†Data from the manufacturers. Data denominator: for HMW and LMW, mg per g fresh weight of edible food; for the rest, mg per g protein of edible food. Protein content (g per 100 g fresh weight of edible food): 95.3, 99.7, 92.7, 91.1, 89.1 and 84.5 for HMW, LMW, whey, casein, soy and pea, respectively.

*Cystine + methionine: 21
**Phenylalanine + tyrosine: 93
Potato protein

- Interesting for weight control or for its technological characteristics
- Less for malnourished persons

He et al. (2013) Int J Food Sci Nutr, 64: 787–793
Duckweed new crop to feed the world?

<table>
<thead>
<tr>
<th></th>
<th>Protein content</th>
<th>Yield biomass (tons dm/ha/y)</th>
<th>Potential protein yield (tons/ha/y)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oil seeds – soybean</td>
<td>45%</td>
<td>1.5-3 tons</td>
<td>0.6-1.2 tons</td>
</tr>
<tr>
<td>Oil seeds – rapeseed</td>
<td>25%</td>
<td>3 tons</td>
<td>0.75 ton</td>
</tr>
<tr>
<td>Oil seeds – sunflower</td>
<td>23%</td>
<td>3 tons</td>
<td>0.7 ton</td>
</tr>
<tr>
<td>Legumes (pulses) – peas/beans/ lupine</td>
<td>17-35%</td>
<td>4-6 tons</td>
<td>1-2 tons</td>
</tr>
<tr>
<td>Legumes (forage) – lucerne</td>
<td>19%</td>
<td>13 tons</td>
<td>2.5 tons</td>
</tr>
<tr>
<td>Cereals – oat</td>
<td>12-15%</td>
<td>3-5 tons</td>
<td>0.4-0.75 ton</td>
</tr>
<tr>
<td>Pseudo cereals – quinoa</td>
<td>12-18%</td>
<td>3 tons</td>
<td>0.4-0.5 ton</td>
</tr>
<tr>
<td>Leaves – grass</td>
<td>12%</td>
<td>10-15 tons</td>
<td>1.2-2 tons</td>
</tr>
<tr>
<td>Leaves – (e.g. sugar beet leaves)</td>
<td>12%</td>
<td>4.5 tons</td>
<td>0.5 ton</td>
</tr>
<tr>
<td>Macro algae - seaweed</td>
<td>10-30%</td>
<td>25 tons</td>
<td>2.5-7.5 tons</td>
</tr>
<tr>
<td>Micro algae</td>
<td>25-50%</td>
<td>15-30 tons</td>
<td>4-15 tons</td>
</tr>
<tr>
<td>Duckweed</td>
<td>35-45%</td>
<td>30-40 tons</td>
<td>10-18 tons</td>
</tr>
</tbody>
</table>

Yield duckweed protein 10 x higher than soybean
Amino acids compared to other crops

- Duckweed comparable (or better) essential amino acids profile than soybean, grains, rice, lentils, spinach

<table>
<thead>
<tr>
<th>Essential amino acids</th>
<th>Seed</th>
<th>Legume</th>
<th>Leaf</th>
</tr>
</thead>
<tbody>
<tr>
<td>%</td>
<td>Grain</td>
<td>Legume</td>
<td>Legume</td>
</tr>
<tr>
<td>Wheat</td>
<td>1.3</td>
<td>1.4</td>
<td>1.6</td>
</tr>
<tr>
<td>Corn</td>
<td>0.1</td>
<td>1.0</td>
<td>1.8</td>
</tr>
<tr>
<td>Rice</td>
<td>1.2</td>
<td>1.0</td>
<td>2.0</td>
</tr>
<tr>
<td>Soy</td>
<td>1.4</td>
<td>4.1</td>
<td>4.9</td>
</tr>
<tr>
<td>Chick pea</td>
<td>1.0</td>
<td>3.8</td>
<td>3.9</td>
</tr>
<tr>
<td>Lentil</td>
<td>1.0</td>
<td>4.9</td>
<td>5.9</td>
</tr>
<tr>
<td>Spinach</td>
<td>1.6</td>
<td>7.7</td>
<td>8.9</td>
</tr>
<tr>
<td>Broccoli</td>
<td>1.8</td>
<td>7.4</td>
<td>6.3</td>
</tr>
<tr>
<td>Duckweed</td>
<td>2.0</td>
<td>7.9</td>
<td>7.0</td>
</tr>
</tbody>
</table>

Edelman & Colt, 2016
Duck weed - very low carbon footprint
Models to study AA

- **Goals of study**
  - Bioavailability of AA during rest and after intense exercise
  - Which proteins/peptides end up directly in blood
  - What is the effect of intense exercise on gut permeability
  - Design products that can reduce unwanted permeability of gut
40g casein 10 trained young males

Δ Plasma AA AUC (umol/ml)
EAA sample verses AUC

EAA in casein

EAA postprandial AUC

\[ R^2 = 0.505 \]
Individual variation

What causes individual variation: processing of given bolus or history of food intake and turnover as response to food load?
Plasma AA levels

Exercise reduce plasma AA likely due to fast utilisation
Exercise induces permeability

Exercise induces intestinal permeability and increases translocation of peptides.

Very hard to study ‘untargeted’ proteins/peptides from food in blood due to high abundance of plasma proteins.

BCM7 that may increase risk of chronic disease (Cieślińska et al., 2007; Cieślińska et al., 2012).

JanssenDuijghuijsen et al. 2016
Already 1 h exercise induces permeability
And induces translocation of allergen

A. Resting condition

B. Exercise condition

C. Peak Ara h 6 (ng/mL)

D. Ara h 6 AUC (ng·min/mL)

E. Time-to-peak (min)

JanssenDuijghuijsen et al. 2017
Permeability markers correlate

Significant correlation between blood allergen, lactulose and L/R ration
Individual variation identifying persons with higher permeability after exercise

JanssenDuijghuijsen et al. 2017
In summary

- To feed the world we have a protein challenge
- Proteins should have a good quality
  - Balance of the essential aa (still new insights)
  - Bioavailability (dynamics)
- Bioavailability and dynamics can be analysed in humans postprandial (reducing the animal based PDCAAS and DIAAS method), preferable by standardized protocol
- Large stable proteins like allergens can end up in blood, permeability is increased by exercise
- Markers available to study intestinal integrity and gut permeability in humans
- Increased knowledge on personal digestion and uptake of amino acids and peptide can help to optimise nutrition and evaluate (new) protein sources
Acknowledgement

**Good Bad Risky project**
- Lonneke JanssenDuijghuijisen
- Klaske Norren
- Stef Koppelman
- Jaap Keijer
- Renger Witkamp
- Harry Wichers

**Duckweed project**
- Ingrid van der Meer
- Adrie van der Werf
- Gertrude Zeinstra
- Ben Witteman
Thank you

Jurriaan.mes@wur.nl
Bioactive collagen peptides in sports nutrition: Impact on muscles tendons and bones

Speaker: Dr. Steffen Oesser, Director, Collagen Research Institute, University of Kiel, Germany
TBC
The role of pre-meal whey protein in post meal glyceamic control and appetite

Speaker: Prof. Emma Stevenson, Professor of Sport and Exercise Science, Institute of Cellular Medicine, Newcastle University, UK
The role of pre-meal whey protein in post-meal glycaemic control and appetite

Prof. Emma Stevenson
Human Nutrition Research Centre
Newcastle University, UK

Vitafoods Europe Education Programme, Geneva, 2017
Overview

• Importance of postprandial glycaemia

• Whey protein and postprandial glycaemia

• Timing of whey protein intake, postprandial glycaemia and appetite

• Whey protein and glycaemia in type II diabetes patients

• Summary and future directions
Physical activity and dietary modification are central to the management and prevention of Type II Diabetes (ADA)
Postprandial glycaemic control

• **Fasting blood glucose** is an important indicator of glycaemic control

• **Postprandial glycaemia** has been demonstrated to be a better predictor of HbA1C (Riddel *et al.*, 2011)

• 5 year follow-up of T2D patients, postprandial glucose concentrations were a stronger predictor of CVD events (Cavalot *et al.*, 2006)
• We spend most of the day in the postprandial state

• Avoiding time spent in hyperglycaemia is of importance

• Dietary approach is the first line of treatment
Whey protein and glycaemic control

Mignone et al., (2015)
Previous studies have administered disproportionate dosages of whey protein (55g) alongside unrealistic HGI test-meals and have used a range of pre-meal timings.
Pre-meal whey protein research

- Realistic portions of whey protein
- Commonly consumed meals
- Effective methodologies
- Appropriate participant groups
Schematic of experimental trial

- Blood Sample
- Visual Analogue Scale

Whey protein (20 g) or placebo drink (trial dependent)

Breakfast
Lunch

Time (min)
Glucose responses to breakfast

(a) Glucose (mmol·l⁻¹) vs. Time (minutes)

(b) AUC (mmol·min⁻¹·l⁻¹) vs. Time (minutes)

- PRE
- DUR
- POST
- CON

Allerton et al., (2016) unpublished data
Insulin responses to breakfast

Allerton et al., (2016) unpublished data
Appetite

Allerton et al., (2016) unpublished data
Second meal effect

(a)

Glucose (mmol·l⁻¹)

Time (minutes)

(b)

AUC (mmol·min⁻¹·l⁻¹)

PRE DUR POST CON

Allerton et al., (2016) unpublished data
Second meal effect

(c) Sample graph showing changes in insulin levels over time (in minutes) with error bars indicating variability.

(d) Bar chart comparing AUC (area under the curve) across different conditions.

Allerton et al., (2016) unpublished data
Summary

- Consumption of whey protein, either before or alongside a mixed-macronutrient breakfast attenuates peak post-prandial glucose excursions in centrally obese, but otherwise healthy males.

- Consuming whey as a preload reduced glycaemia over 3 hrs compared to the same breakfast with no protein.

- No second meal effects or impact on subjective measures of appetite were observed.
The effect of whey protein on postprandial glycaemia and appetite in Type 2 Diabetes patients
Participants

- 11 male Type 2 Diabetes patients
- Treated by either dietary and lifestyle modification ($n = 3$) or metformin administration ($n = 8$), only.

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (y)</td>
<td>54.9 ± 7.5</td>
</tr>
<tr>
<td>Height (m)</td>
<td>1.8 ± 0.1</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>97.9 ± 22.7</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>31.8 ± 8.7</td>
</tr>
<tr>
<td>HbA1C (%)</td>
<td>6.8 ± 1.0</td>
</tr>
</tbody>
</table>

CGMS (Dexcom G4, USA) fitted 36 h prior to experimental trials
Schematic of experimental trial
Data presented as mean ± SEM. Grey= control, orange= hydrolysed, blue= whey

King et al., (2017)
- Greater amount of time spent in euglycaemic ranges in whey trials compared to control
- Shorter duration spent within hyperglycaemic ranges in whey trials compared to control

King et al., (2017)
Insulin responses

**Breakfast**

**Lunch**

Data presented as mean ± SEM. Grey = control, orange = hydrolysed, blue = whey

King et al., (2017)
Plasma incretin responses

Data presented as mean ± SEM. Grey = control, orange = hydrolysed, blue = whey

King et al., (2017)
Appetite responses - breakfast

Data presented as mean ± SEM. Grey = control, orange = hydrolysed, blue = whey

King et al., (2017)
Appetite responses - lunch

Hunger

Fullness

Satisfaction

Prospective intake

Data presented as mean ± SEM. Grey = control, orange = hydrolysed, blue = whey

King et al., (2017)
Summary

• A small amount of whey protein reduced early postprandial glycaemia – more pronounced at breakfast than at lunch

• Small insulinotrophic effect of whey protein

• No effect of whey protein on incretin hormones

• Limited effect of whey protein on subjective appetite
Conclusions

Whey protein, when administered at meal times, resulted in a small reduction in early postprandial glycaemia in type II diabetes patients
Opportunities for industry?

- Optimal dose and timing of whey protein intake
- Form of protein intake - **commercially viable**
- Amino acid combinations – can they be effective for improved glycaemic control?
- Whey protein as part of a healthy lifestyle – exercise and diet interactions
Q&A
Protein Industry Success Story: Maintaining muscle health in ageing: The role of HMB

Speaker: Dr. Ralf Jäger, Senior Scientific Advisor, TSI Health Sciences Europe, USA
Gracefully Aging

Consumers want to maintain and improve energy, mobility and independence as they age. They want to feel youthful, stay active and avoid injury.
Gracefully Aging: What’s stopping them?

• Age-Related Cognitive Decline (Dementia)
• Age-Related Macular Degeneration
• Age-Related Bone Loss (Osteoporosis)
• Age-Related Degenerative Joint Health
• **Age-Related Muscle Loss (Sarcopenia)**
• ...
Why muscle health?

Skeletal muscle makes up 30–40% of your body mass

- Responsible for all movement and support
- Essential to metabolic function, endurance and strength
- Essential to overall health and well-being
The average person loses 1.5% muscle mass every year, with acceleration after age 40.
The average average person loses 35–40% of their muscle mass and 20–40% of their strength between the ages of 20 and 80.
What does it mean to lose muscle mass?

1. **Healthy Body Composition**
   40 percent of overall body mass is skeletal muscle.

2. **60 Years of Muscle Loss**
   Only 24 percent of overall body mass is skeletal muscle.
Why does muscle loss happen?

Muscle loss is a natural part of life and inherent as we age. However, there are other factors which contribute to degradation of muscle health:

- Illness or injury (muscle disuse atrophy)
- Excessive physical stress (overtraining)
- Calorie restriction
- Loss of appetite/reduced nutrient (protein) intake
Muscle loss affects more than just strength.
HMB ...

- Beta-hydroxyl-beta-methylbutyrate (HMB) is a naturally occurring metabolite of the essential amino acid leucine
- Most foods contain trace amounts of HMB
  - Meats: 15-25 nmol/g
  - Fruits & vegetables: 1-5 nmol/g
  - Some foods of plant origin have concentrations of HMB comparable to meats:
    - herbal tea: 26 nmol/g
    - asparagus and squash: 22 nmol/g
HMB ...

- Endogenous production of HMB occurs in muscle and liver.
- Transamination of leucine to KIC, 10% of KIC is oxidized to HMB in the cytosol (5% of leucine is converted to HMB).
- A 70-kg human produces 0.2 to 0.4 g HMB per day, depending on leucine intake.
- 60 grams of leucine, or 600g of whey protein are needed to get 3 grams of HMB.
- Supplementation with HMB needed to improve muscle health.
Mechanism-of-Action

- Muscle mass is the sum of muscle protein breakdown and synthesis
- HMB decreases muscle protein breakdown & amps up muscle protein synthesis
- HMB supplementation increases muscle mass, strength and power

Absorption

- Plasma levels are elevated in as little as 30 min
- Peak concentration at approximately 2 hours post ingestion
- Concurrent Glucose ingestion (75g) does not increase absorption

- Absorption of supplementary HMB is excellent
  - @ single dose 1g: 14% is excreted in the urine
  - @ single dose 3g: 29% is excreted in the urine

- To optimize HMB absorption, take split doses of 1g 3x per day

Delivery forms: Calcium salt vs. free acid

- **Traditional Delivery Form:**
  Calcium Salt of HMB
  - CaHMB
  - White, crystalline powder

- **Improved Delivery Form:**
  Beta-Hydroxy-Beta-Methylbutyric Acid
  - HMB Free Acid
  - Viscous, clear to light yellow tinted liquid

- HMB free acid resulted in quicker and greater plasma concentrations (97 %) and improved clearance (25 %) of HMB from plasma.
- HMB free acid peaks faster (approx. 30 min vs. 2-3 hours)

Dosing

- Untrained males, 19-29 years of age (subjects that participated in a resistance-exercise program in the last 3 months were excluded)
- 0, 1.5 or 3g of HMB for 3 weeks.
- Weight training 3 days per week.
- Total strength increased by 8% (placebo), 13% (1.5g) or 18.4% (3g).
- LBM increased 0.4kg (placebo), 0.8kg (1.5g) or 1.2kg (3g).

Benefits in Athletes

Resistance Training Athletes

- HMB decreases muscle protein breakdown and stimulates protein synthesis.
- HMB supplementation increases muscle mass, strength and power.

Endurance Athletes

- HMB improves mitochondrial biogenesis and energy metabolism.
- HMB supplementation increases aerobic capacity.

- HMB protects resistance and endurance athletes from exercise-induced muscle damage.
- HMB helps athletes to maintain muscle mass and strength during calorie restriction.
Clinically proven benefits

• Boosts protein synthesis (Eley, 2007)
• Reduces protein breakdown (Smith, 2005)
• Improves recovery by reducing muscle damage (Knitter, 2000; Jowko, 2001)
• Improves strength
• Improves body composition while increasing fat loss
• Improves strength gains from resistance training (Nissen, 2003)
  
  Improves endurance (Lamboley, 2007; Vukovich, 2001)
• Improves anabolic effects of plant-based protein (N. Rittig, 2016)
Goals for muscle health in the elderly

• Retain lean muscle
• Improve muscle recovery after exercise, injury or illness
• Improve mobility
• Improve strength and stability
• Maintain physical independence
Muscle health in the elderly

- Randomized, double-blind, placebo-controlled, parallel design
- 35 elderly men and women (HMB 71 ± 5 years, Placebo 74 ± 4 years)
- 3.0 grams of Ca-HMB were provided daily for 8 weeks
- 8 weeks of resistance training on 10 Keiser™ isotonic machines, designed to isolate all major muscle groups
- All of the above parameters except for walking time significantly improved. HMB significantly improved GUG over control: -6%. (time to get out of a chair, walk 6.6 m, turn around, walk back to the chair, and sit down)
- Ca-HMB supplementation may increase functional ability of elderly adults.

Muscle health in the elderly

- Randomized, double-blind, placebo-controlled, parallel design
- 31 70-year-old adults undergoing a 5 d/week exercise program
- 3.0 grams of Ca-HMB were provided daily for 8 weeks.
- HMB supplementation tended to increase fat-free mass gain. Furthermore, HMB supplementation increased the percentage of body fat loss compared with the placebo group. CT scans also indicated a greater decrease in the percentage of body fat with HMB supplementation.
- Ca-HMB supplementation may improve body composition in elderly participating in a strength training program as well as may decrease fat mass and increase fat loss in elderly, and may increase hamstring strength in elderly.

Muscle health in the elderly

- Randomized, double-blind, placebo-controlled design.
- **Phase 1:** 2 non-exercise groups: 3 g Ca-HMB or Placebo
- **Phase 2:** 2 resistance exercise groups: 3 g Ca-HMB or Placebo
- At 24 weeks of Phase 1, change in leg extension and leg muscle quality for Ca-HMB was significantly greater than placebo group.
- Phase 2 demonstrated that resistance exercise significantly improved total lean mass, leg extension/flexion, handgrip strength, and get-up-and-go, with no difference between treatment groups. At week 24, only the Ca-HMB group significantly improved total fat mass and arm muscle.
- Ca-HMB supplementation improves total lean mass, leg extension/ flexion, strength and muscle quality without resistance exercise.

Muscle health in the elderly

- Parallel-group, randomized, controlled, open-label trial
- 65 Older women (mean 69.5±5.3 years of age)
- Supplement containing 1.5 g of Ca-HMB for 8 weeks
- Ca-HMB supplementation
- No significant effects on SPPB (Short Physical Performance Battery)
- Significantly improved muscle strength and physical performance parameters

Muscle disuse atrophy in the elderly

- Healthy older adults have been reported to lose approximately one kilogram (2.2 pounds, about 6%) of lean tissue from the lower extremities after 10 days of bed rest, with an associated 16% decline in isokinetic knee extensor strength.
- Randomized, double-blind, placebo-controlled, parallel design
- 24 healthy older (60-76 years) adult subjects (20 women, 4 men), confined to complete bed rest for ten days, followed by resistance training rehabilitation for 8 weeks. 19 participants were evaluable after 10 days of bed rest.
- 3.0 g of Ca-HMB were provided starting 5 days prior to bed rest till the end rehabilitation phase.

Calorie restriction

• 4 groups

- All you can eat + training
- All you can eat + training + HMB
- 30% calorie restriction + training
- 30% calorie restriction + training + HMB

• HMB prevented calorie restricted loss in muscle mass

• HMB prevented calorie restricted loss in grip strength

Calorie restriction

• 3 grams HMB for 3 days during calorie restriction in female judo athletes
• HMB helps to reduce body fat (BF): -5.0%
• HMB prevents calorie restricted loss in grip strength: +2.8% vs. -3.8%

<table>
<thead>
<tr>
<th>Treatment</th>
<th>BF</th>
<th>Muscle Mass</th>
<th>Peak Power</th>
<th>Grip Test</th>
<th>10-m Shuttle Run</th>
</tr>
</thead>
<tbody>
<tr>
<td>HMB</td>
<td>-5%</td>
<td>-0.6%</td>
<td>-5.2%</td>
<td>+2.8%</td>
<td>-3.6%</td>
</tr>
<tr>
<td>Placebo</td>
<td>No Change</td>
<td>-1.4%</td>
<td>-10.8%</td>
<td>-3.8%</td>
<td>-5%</td>
</tr>
</tbody>
</table>

Benefits of Vitamin D

- Serum levels of at least 32 ng/mL are necessary for optimal muscle function (Larson-Meyer, 2010)
- Recent publication reported that over half of all athletes studied have less than optimal Vitamin D levels (Farrokhyar, 2015)
Optimizing Benefits of HMB in Elderly

HMB alone has been shown to increase muscle strength ...

... but maximum benefits were realized in a study when participants had adequate levels of Vitamin D.

Creatine

- Mechanism-of-action?
  - Increases re-synthesis of ATP from ADP

- Optimal dose?
  - Loading: 4 x 5g for 5-7 days,
    Maintenance: 3-5g per day
  - Without loading: 3-5g per day (28 days)

- When (nutrient timing)?
  - “Immediately post workout”

- Expected benefit: improves
  - maximal power/strength (5–15%),
  - work performed during sets of maximal effort muscle contractions (5–15%),
  - single-effort sprint performance (1–5%),
  - work performed during repetitive sprint performance (5–15%).

HMB and Creatine: Additive Benefits

- 3-week resistance-exercise training
- 7d 20g, 14d 10g of creatine (CR), or 3g of HMB, or CR plus HMB, or placebo, 40 subjects.
- CR (0.39 kg), HMB (0.92 kg) and CR+HMB (1.54 kg) increased lean body mass (LBM)
- CR (37.5 kg), HMB (39.1 kg) and CR+HMB (51.9 kg) increased strength (weight lifted).
- Effects of CR and HMB are additive indicating different mechanism-of-action

Adenosine Triphosphate

- ATP is the cell’s energy currency
- Human body contains approx. 250 g of ATP
- Daily turnover: roughly the body’s weight

**Mechanism-of-Action**

1. Increases Blood Flow
2. Increases Muscular Excitability
3. Anabolic Signaling

**Clinical Proven Benefits**

- Improve Blood Flow
- Increase Total Strength by 147%
- Increase Vertical Jump Power by 30%
- Increase Lean Body Mass by 100%
- Increase Muscle Thickness by 96%
- Reduce Muscular Fatigue
- Increase Muscular Excitability
- Increase Peak Power
- Increase Post-Exercise ATP Levels
- Increase Recovery and Reduce Pain

HMB and ATP: Synergistic Benefits

- More than **triples the strength gains** from resistance training (+329%, 96.0kg vs. 22.4kg (Placebo))
- Improves Body Composition – More than **triples the increases in lean body mass** from resistance training (+305%, 8.5kg vs. 2.1kg (Placebo))
- **Synergistically Improves Power** by 75% (1,076±40 watts vs. 614±52 watts (Placebo))
- **Boosts Muscle Thickness** by 212% (7.8±0.4 mm vs. 2.5±0.6 mm (Placebo))

HMB and sarcopenia

- Reducing muscle breakdown
- Benefits in elderly
  - maintaining muscle mass
  - maintaining strength
  - improving body composition
  - improving daily activities
- Dosing: 1.5g-3.0g per day
Q&A
Panel Discussion

Chair: **Suzane Leser**, Vice-Chair, **European Specialist Sports Nutrition Alliance (ESSNA)**, UK

Speaker: **Dr. Jurriaan Mes**, Senior Scientist Food Quality & Health Effects, **Wageningen Food & Biobased Research**, Netherlands

Speaker: **Dr. Steffen Oesser**, Director, Collagen Research Institute, **University of Kiel**, Germany

Speaker: **Prof. Emma Stevenson**, Professor of Sport and Exercise Science, Institute of Cellular Medicine, **Newcastle University**, UK

Speaker: **Dr. Ralf Jäger**, Senior Scientific Advisor, **TSI Health Sciences Europe**, USA
DISCOVER OUR GLOBAL NETWORK

Informa Exhibitions’ Global Health & Nutrition Network creates and delivers highly specialised information for the health and nutrition marketplace through events, digital media and publishing to provide business, learning and networking opportunities.

EVENTS

SupplySide® WEST
25-29 September 2017
Mandalay Bay
Las Vegas, USA

Vitafoods Europe
SEE YOU NEXT YEAR!
15-17 May, 2018

Vitafoods Asia
5-6 September 2017
Marina Bay Sands
Singapore

SupplySide® EAST
10-11 April 2018
Meadowlands Exposition Center
Secaucus, New Jersey, USA

MATERIALS

Vitafoods Insights offers an online destination that delivers the best content from Vitafoods events to a global audience.

Natural Products INSIDER is the leading media resource for marketers, manufacturers and formulators of dietary supplements, functional foods and beverages, sports nutrition products and cosmeceuticals.

Food INSIDER JOURNAL

Natural Products INSIDER is the leading media resource for marketers, manufacturers and formulators of dietary supplements, functional foods and beverages, sports nutrition products and cosmeceuticals.

SupplySide & Vitafoods GLOBAL STOREFRONTS

SupplySide & Vitafoods Global Storefronts is the online tool you need to search for new ingredients and solutions and to launch new products and innovations.