Collagen: Potential health and performance benefits in sports

Speakers:
- Koen Vanhoutte – PB Leiner
- Professor Robert C. Hickner – Florida State University
AGENDA

1. Tessenderlo Group and PB Leiner
2. SOLUGEL® Collagen Peptides
3. Collagen: Potential health and performance benefits in sports
4. Thinking of empowering your sports formulations with collagen?
Tessenderlo Group

1919

FROM A CHEMICAL COMPANY ...

... INTO A DIVERSIFIED INDUSTRIAL GROUP

serving customers in

AGRICULTURE  INDUSTRY  CONSTRUCTION  HEALTH  CONSUMER GOODS END MARKETS
PB Leiner – global presence and local knowledge

- Collagen and gelatin
- 7 factories
- >150 years of experience
- Premium quality
- Technical know-how
- Application expertise

Davenport (USA)
Santa Fe (Argentina)
Acorizal (Brazil)
Treforest (UK)
Vilvoorde (Belgium)
HQ/R&D Center
Nienburg (Germany)
Nehe (China)

Plants with collagen production
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SOLUGEL® collagen peptides

The clear solution for your applications

- Obtained from natural sources in line with highest safety standards
- Premium raw material and specialized production process
- Halal, kosher, and pasture-raised products available
- Ideal for integration in supplements, snacks, food and beverages

SOLUGEL® product portfolio

<table>
<thead>
<tr>
<th>Raw Material</th>
<th>Product portfolio</th>
<th>Powder characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bovine</td>
<td>SOLUGEL®</td>
<td>Agglomerated and fine powder</td>
</tr>
<tr>
<td>Porcine</td>
<td>SOLUGEL®</td>
<td>Agglomerated and fine powder</td>
</tr>
</tbody>
</table>
SOLUGEL® collagen peptides

Dissolution Series

- PB Leiner’s latest premium collagen product offering
- Excellent dissolution, neutral flavour and taste
- Made of high-quality bovine and porcine materials
- Dust-free and lump-free
- Ideal for “instant” applications such as protein shakes and smoothies
# SOLUGEL® collagen peptides

The clear solution for your health!

<table>
<thead>
<tr>
<th>Health benefits</th>
<th>Dosage</th>
<th>Effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beauty</td>
<td>5-10 g/day, 3 months</td>
<td>• Wrinkles reduction</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Increased hydration</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Increased skin elasticity</td>
</tr>
<tr>
<td>Joints</td>
<td>10 g/day, 4-6 months</td>
<td>• Healthy joints</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Anti-inflammatory effect</td>
</tr>
<tr>
<td>Bone health</td>
<td>5-10 g/day, 6-12 months</td>
<td>• Increased bone mineral density</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Strengthen bones</td>
</tr>
<tr>
<td>Wound healing</td>
<td>10 g/day, 4 months</td>
<td>• Speed up and improve ulcers’ healing</td>
</tr>
<tr>
<td></td>
<td>15 g/day, 2 months</td>
<td></td>
</tr>
<tr>
<td>Satiety</td>
<td>15 g/day</td>
<td>• Reduced calorie intake due to the satiety effect</td>
</tr>
</tbody>
</table>

*Scientific studies supporting these arguments available upon request (info@pbleiner.com)
Collagen is on trend - A growing market

This slide shows Google trends done by web search globally using key words (ingredients) in order to give indication of popularity of the different ingredients.

Proteins ingredients’ popularity by Google Trends

Source: Google Trends 2019 Feb

Numbers represent search interest relative to the highest point on the chart for the given region and time. A value of 100 is the peak popularity for the term. A value of 50 means that the term is half as popular. Likewise a score of 0 means the term was less than 1% as popular as the peak.
Collagen is on trend - A growing market

This slide shows Google trends done by web search globally using key words (ingredients) in order to give indication of popularity of the different ingredients.

Joint health ingredients’ popularity by Google Trends

Source: Google Trends 2019 Feb
Numbers represent search interest relative to the highest point on the chart for the given region and time. A value of 100 is the peak popularity for the term. A value of 50 means that the term is half as popular. Likewise a score of 0 means the term was less than 1% as popular as the peak.
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Professor Robert C. Hickner

Our guest speaker

- Education: Indiana University (B.S. Biological Sciences), Ball State University (M.S. Biology/Exercise Physiology), and The Karolinska Institute (PhD Medical Sciences)

- Postdoctoral training at Washington University School of Medicine

- Professor at Florida State University - Department of Nutrition, Food & Exercise Sciences

- Lifelong multi-sport athlete (Former Hawaii Ironman World Championship Triathlon competitor)
Collagen: Potential health and performance benefits in sports

Professor Robert C. Hickner – Florida State University
Outline

1. Background and Composition of Collagen
2. Collagen absorption (bioavailability)
3. Peptide appearance in blood and effect on ligaments
4. Collagen and Inflammation
5. Collagen affects on tissue function and return to play
6. Summary
Sports nutrition market value increased from 7.3 billion USD in 2011 to 13.6 Billion USD in 2017. Anticipated to grow >8% through 2022.

33 million musculoskeletal injuries have been reported, 50% involving tendon and ligament injuries. 10% of men and 13% of women 60 years or older experience osteoarthritis.

Wu et al, 2017 EFORT
Collagen...

70% of skin
30% of bone
80% of Tendons/Ligaments
>30% of total protein in the body

Collagen can also be found in eyes, ear/nose cartilage, teeth, lungs, blood vessels, muscles ...

COLLAGEN IS THE BUILDING BLOCK OF OUR BODY
Collagen hydrolysate

• Dietary supplement that may be beneficial in athletes, recreational exercisers, or in individuals suffering from degenerative joint disease.

• Made out of collagenous tissue from porcine, beef, fish sources
  – Bone, hide, and hide split.

• Collagen hydrolysate range in size from 0.5-13.5 kilodaltons
  – Average 3.3 kilodaltons

• Can be easily dissolved in water
# Amino Acid Composition of Collagen Peptide

Oikawa et al, 2018

## Amino acid composition of protein supplements

<table>
<thead>
<tr>
<th></th>
<th>WP supplement</th>
<th>CP supplement</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>g/100 g</td>
<td>g/30 g</td>
</tr>
<tr>
<td>Alanine</td>
<td>5.7</td>
<td>1.7</td>
</tr>
<tr>
<td>Arginine</td>
<td><strong>3.0</strong></td>
<td><strong>0.9</strong></td>
</tr>
<tr>
<td>Aspartic acid</td>
<td>12.5</td>
<td>3.8</td>
</tr>
<tr>
<td>Cystine</td>
<td>4.0</td>
<td>1.2</td>
</tr>
<tr>
<td>Glutamic acid</td>
<td>17.6</td>
<td>5.3</td>
</tr>
<tr>
<td>Glycine</td>
<td><strong>1.8</strong></td>
<td><strong>0.5</strong></td>
</tr>
<tr>
<td>Histidine</td>
<td>2.0</td>
<td>0.6</td>
</tr>
<tr>
<td>Proline</td>
<td>4.5</td>
<td>1.4</td>
</tr>
<tr>
<td>Serine</td>
<td>4.5</td>
<td>1.4</td>
</tr>
<tr>
<td>Tyrosine</td>
<td>4.2</td>
<td>1.3</td>
</tr>
<tr>
<td>Tryptophan</td>
<td>2.4</td>
<td>0.7</td>
</tr>
<tr>
<td>Isoleucine</td>
<td>6.3</td>
<td>1.9</td>
</tr>
<tr>
<td>Leucine</td>
<td>14.3</td>
<td>4.3</td>
</tr>
<tr>
<td>Lysine</td>
<td>11.2</td>
<td>3.4</td>
</tr>
<tr>
<td>Methionine</td>
<td>2.4</td>
<td>0.7</td>
</tr>
<tr>
<td>Phenylalanine</td>
<td>3.8</td>
<td>1.1</td>
</tr>
<tr>
<td>Threonine</td>
<td>5.3</td>
<td>1.6</td>
</tr>
<tr>
<td>Valine</td>
<td>5.6</td>
<td>1.7</td>
</tr>
<tr>
<td>ΣEAAAs</td>
<td>51.3</td>
<td>15.4</td>
</tr>
<tr>
<td>ΣNEAAs</td>
<td>59.8</td>
<td>17.9</td>
</tr>
</tbody>
</table>

1CP, collagen peptide; EAA, essential amino acid; NEAA, nonessential amino acid; WP, whey protein.
Creatine is produced from glycine, arginine and methionine. **Collagen hydrolysate** boosts amino acid precursors of creatine.
Doses found in literature

5-20g of collagen peptides for joint health
Taken daily
3-6 months
Collagen hydrolysate absorption (bioavailability)

- Collagen hydrolysate readily passes across the mucosal barrier in the small intestine as a complete peptide.
- Stimulate the production of collagen and proteoglycans in the extracellular matrix of cartilage.
- Peptides accumulate in cartilage.
- No longer subject to further breakdown in tissues.

Clark et al, 2008
Detection of novel collagen peptides in circulation

• Proline-containing dipeptides, such as Proline-Hydroxyproline (Pro-Hyp) in collagen, may contain cyclic structures during digestion and absorption (Taga et al., 2017).

Aims:
• Can cyclic Pro-Hyp be detected in circulation after collagen hydrolysate ingestion?
• Do the cyclic structures alter biological activity in vitro?

Ingestion of 5 g collagen hydrolysate dissolved in 200 mL water

Fasting for 12 h  Blood collection  Preparation of the ethanol-soluble plasma fraction

0 30 60 120 240 360 480 min

Shigemura et al., 2018
Biological activity of cyclic peptides

Similar pattern between linear and cyclic Pro-Hyp appearance in plasma. Peak at 2 hours.

Linear vs. cyclic pro-hyp effects on fibroblast growth rate

Figure 6. Changes in the average concentrations of linear (A) and cyclic (B) Pro-Hyp in human plasma of five volunteers. Data are shown as means ± SDs (n = 5). Different letters adjacent to data points indicate significant differences (P < 0.05).

Figure 7. Growth rates of mouse skin fibroblasts on collagen gel. Growth rates were estimated after 0, 1, 2, and 4 days of incubation in the presence of linear (●) and cyclic (▲) Pro-Hyp or in the absence (■) of both peptides. ** and * indicate significant differences (P < 0.01 and P < 0.05, respectively).

Shigemura et al., 2018
To summarize...

- Typical dosages of collagen hydrolysate: 5-20g daily
- Plasma concentrations of collagen peptides peak at 2 hours
- Collagen peptides reach the target tissues: ligaments, tendons, cartilage
- Some peptide structures present in collagen hydrolysate might be more effective than others
Collagen supplementation effects on tissues structure
Collagen protein supplementation augments collagen synthesis

**FIGURE 1** Schematic timeline of the study. PINP, N-terminal peptide of pro-collagen I.
Engineered ligaments treated for 6 days with participant serum showed increased collagen content.
Joint health, inflammation and progressive damage

The course of degenerative alterations in articular cartilage is characterized by an imbalance between matrix degradation and the regeneration of the extracellular matrix (ECM).

ECM formation by chondrocytes decreases progressively due to aging and other factors affecting cartilage, like physical activity.
Collagen and inflammation

- Glycine is one of the major structural units of collagen.
- Collagen hydrolysate (CH) ingestion increases systemic glycine levels in a concentration dependent manner.
Glycine has an **anti-inflammatory** effect

- Glycine acts as an **inhibitory neurotransmitter** in the central nervous system via glycine-gated chloride channels.

- Modulation of the **inflammatory response** by collagen hydrolysate (via glycine) may contribute to the protective effectiveness on osteoarthritis.

## Collagen hydrolysate reduces plasma IL-6

Adapted from Hartog et al. 2013
24-week Study of CH in athletes with activity-related joint pain

6 parameters improved over 24 weeks in college athletes: Joint pain at rest (assessed by physician), joint pain (assessed by participant) when walking, standing, at rest, when carrying objects, when lifting

Clark et al., 2008
Effect on isokinetic leg strength in groups treated for 14-weeks with collagen hydrolysate or placebo

Zuckley et al., 2004
Collagen and appetite

- Collagen hydrolysate (CH), CH with tryptophan (CH+Trp), and alpha-lactalbumin may be up to 40% more satiating than other proteins (casein, soy, whey).

- CH, CH+Trp, and alpha-lactalbumin induced a 20% reduction of subsequent energy intake. Long term effect on body composition?

Adapted from Veldhost et al. 2009
Summary

- Collagen peptide contains an amino acid composition that may be beneficial not only for collagen synthesis but also for metabolic health.

- Collagen hydrolysate may reduce inflammation and result in novel cyclic peptides with unique collagen stimulating properties.

- Collagen addition to routine clinical care may:
  - Reduce joint pain
  - Improve ligament, tendon, cartilage and muscle structure and function
  - Result in sooner athlete return to play
Advice suggested from the literature

- Thirty to sixty minutes before training, consume approximately 15 g of collagen hydrolysate in either a liquid or gel form.

- The exact amount of collagen hydrolysate may depend on body mass and is yet to be fully determined.

- Blood flow may be limited following exercise, so nutritional intervention designed to target tendons/ligaments should be in place prior to exercise.

Baar, Sports Med. 2017
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We can guide you through!
Thinking of empowering your sports formulations with collagen?

Explore our innovative product concepts in sports nutrition