TATE & LYLE

Oat Protein: Health Benefits and Product Applications

Innovating to Meet Nutrition, Health, and Wellness Needs Every Day

PrOatein™ Oat Protein

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proatein™ Oat Protein

Protein Intake Recommendations and Needs

- **Protein is an important part of the diet and plays essential roles in the body, both structurally (muscle and bone) and functionally (biochemical processes, neurotransmission, circulation)**
- **The branched chain amino acids (BCAAs) leucine, isoleucine, and valine stimulate and support muscle protein synthesis (MPS), a process that is important for maintaining muscle structure and function, and are critical for muscle growth and repair at all ages**
- **Meta-analyses and clinical studies indicate some favourable effects of higher protein versus lower protein diets on health outcomes including adiposity and cardiovascular risk factors**
- **It is recognised that dietary proteins may induce satiety in humans and thus may help with maintenance of body weight**
- **PrOatein™ Oat Protein contains significant amounts of indispensable BCAAs and can serve as a vegan-friendly protein source for a variety of beverage and food applications**

Protein as a macronutrient

Protein is an important macronutrient in the diet and is required to meet nutritional needs and to support health and well-being[1]. This macronutrient is needed to meet human nitrogen requirements and provide indispensable amino acids (also known as essential amino acids). Amino acids (AA) are classified as those that cannot be synthesised by the body (indispensable or essential) and those that the body can synthesise (dispensable or nonessential)[2]. However, some are also conditionally indispensable, becoming essential under specific pathological or physiological conditions[2]. Protein is an important structural and functional component of organs, muscles, biological fluids, and hormones[2,3].

Tate & Lyle's PrOatein™ Oat Protein, like the oat grain it comes from, contains significant amounts of dietary indispensable branched chain amino acids (BCAAs). PrOatein™ Oat Protein is a natural protein concentrate ingredient from oats, which can help meet the fast-growing consumer demand for products containing oats and protein-enriched foods.

Global protein intakes

The 2007 World Health Organisation (WHO) Technical Report on protein and amino acid requirements for human nutrition estimates that the average protein requirement for maintenance is 105 mg nitrogen per kg body weight per day, or 0.66 g protein per kg body weight per day[4]. In the developed world, animal food products are the predominant sources of protein followed by cereals, whereas in developing countries this order is reversed. In countries with lower average income, 3% of total dietary energy is from animal protein sources; 11% is from roots and tubers; 6% is from pulses, nuts, and oilseeds; and the remainder is primarily from cereal-based staple foods[5]. Although the production of livestock has increased in developing countries, the consumption of protein in these countries remains inadequate[5]. Additionally, the protein consumed is generally low quality, lacking some of the amino acids required for proper growth and development[5].

Not every protein source provides all of the amino acids needed for growth and development, and not all protein is equally bioavailable from food sources; however, bioavailability can change with food processing[6-8].

Protein quality

Protein digestibility, a component of protein quality, determines the amount of ingested amino acids that are available to the body after digestion and absorption[7]. Ileal digestibility is the current recommended method for determination of dietary amino acid digestion (further described on the next page), and high levels of digestibility are characteristic for animal proteins and certain purified and concentrated vegetable proteins[4,7].

Table 1

Recommended amino acid scoring patterns[a]

	Scoring pattern (mg/g protein) requirements								
Age groups	**His**	**Ile**	**Leu**	**Lys**	**SAA[b]**	**AAA[c]**	**Thr**	**Trp**	**Val**
Child (aged 6 months to 3 years)	20	32	66	57	27	52	31	8.5	43
Older child, adolescent, and adult (> 3 years of age)	16	30	61	48	23	41	25	6.6	40

[a] Adapted from Chapter 4, Table 5 of the 2013 FAO report.
[b] Sulfur Amino Acids: Methionine and Cysteine
[c] Aromatic Amino Acids: Phenylalanine and Tyrosine

The Food and Agriculture Organisation (FAO) of the United Nations Expert Consultation on Protein Quality Evaluation, in conjunction with the WHO, reviewed protein quality assessment of foods and specifically evaluated the amino acid scoring used[9]. Based on this review, the 1991 Consultation Report was released, which concluded that the Protein Digestibility-Corrected Amino Acid Score (PDCAAS) method, which adjusts amino acid content of the protein source by faecal digestibility correction, was the most suitable approach for routine evaluation of protein quality for humans[2,9-11]. This method compares the indispensable amino acid content of the protein source to a reference value for each amino acid based on nutritional needs and corrects for the digestibility of the protein; this method is also recommended by the Codex Committee on Vegetable Proteins[11].

An update to this FAO/WHO report was published in 2013 and recommended that true ileal digestibility of amino acids from protein sources be accounted for rather than the overall faecal digestibility of a protein[1]. The updated report also includes the adjusted amino acid adequacy reference value recommendations by age group. The current FAO/WHO recommendations by age group are shown in Table 1.

The amino acid content of a protein is compared to the reference amino acid profile to determine if it is a nutritionally adequate protein (also known as a complete protein). Complete proteins provide all indispensable amino acids in the proportion that best supports human growth and development; this is then further corrected for the digestibility of the protein.

FAO/WHO now considers the digestible indispensable amino acid score (DIAAS), adjusted for ileal digestibility, to be a replacement for the PDCAAS[1,2,7,10]. However, PDCAAS is still widely used and more prominent than DIAAS.

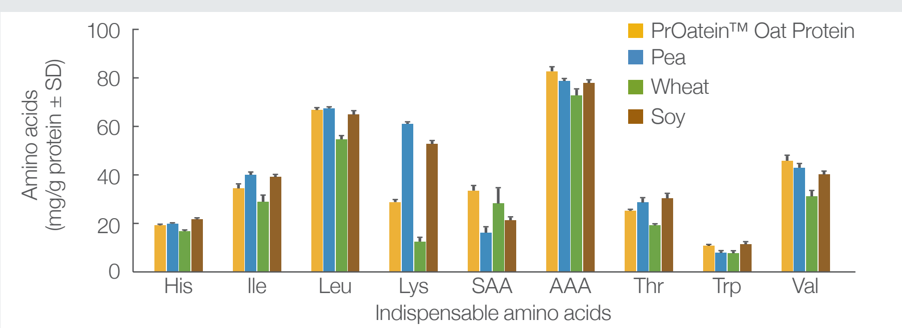
PrOatein™ Oat Protein meets nearly all of the FAO 2013 amino acids pattern requirements for adults except for lysine, the limiting amino acid in oat protein. PrOatein™ Oat Protein contains at least 10% more sulfur amino acids (SAA) and tryptophan than pea protein; more SAAs and valine than soy protein; and has more of each indispensable amino acid compared to wheat (Figure 1). Combining plant proteins can create a more complete amino acid content in finished food products.

Protein consumption needs for younger populations

Both the quantity and quality of the protein consumed is important to early growth and development as it is well-recognised that protein consumption during this development window can have effects on long-term health, including influencing body composition[12]. The recommended protein intake for children at two years of age is 0.97 g/kg body weight to ensure adequate intake, which is greater than the minimal amount of protein required for growth[12]. Additionally, the recommended amino acid scoring patterns for young children (aged three years and younger) were revised in the 2013 FAO/WHO report (Table 1)[1]. Protein requirements are greater during periods of rapid growth related to the increased demands of growth and increases in body mass and height (see Table 2); furthermore, development of muscles require additional amino acids[4].

Figure 1

Indispensable amino acid contents of selected vegetable protein ingredients[a,b]



[a]Three market comparison samples were obtained for soy, pea, and wheat (n=3 for each, n=6 for oat protein).
[b]The amino acid analyses were run at Medallion Laboratories (Minneapolis, MN) per their SOP using validated methods (AOAC Official Method 994.12): Amino Acids- Acid Hydrolysed Amino Acid Profile, Tryptophan, Cysteine and Methionine, and total protein by Dumas (using AOAC method 992.15).

Table 2

Protein requirements (g/kg/day)[4]

Age	Maintenance	Growth	Total Need
Birth to 6 months	0.66	0.46	1.12
1 to 2 years	0.66	0.20	0.86
3 to 10 years	0.66	0.07	0.73
11 to 14 years	0.66	0.07	0.73
15 to 18 years	0.66	0.04	0.70
18 years and older	0.66	0.00	0.66

Protein Consumption and Health Benefits

Increased protein consumption benefits for older populations

Current evidence suggests that older adults (aged 65 years and older) may need more dietary protein than younger adults to support good health, promote recovery from illness, prevent age-related muscle loss, and maintain muscle functionality[13,14]. Ageing muscle is less sensitive to the presence of amino acids and may require higher quantities of protein to stimulate muscle protein synthesis (MPS) and accrue muscle proteins[15]. Older adults also may need more protein to offset conditions associated with chronic and acute diseases that commonly occur with advanced age[13,16,17]. A recent systematic review examined the health effects of protein intake in healthy elderly adults and found that optimal protein intake is likely higher than the current estimated average requirement (EAR) based on nitrogen balance studies[16].

The European Union Geriatric Medicine Society, in cooperation with other scientific organisations, appointed an international group of experts representing a wide range of clinical and research areas, including geriatrics, internal medicine, endocrinology, nutrition, exercise physiology, gastroenterology, and nephrology, to review dietary protein needs with ageing[13]. This appointed international PROT-AGE Study Group published evidence-based recommendations in 2013 for optimal protein intake by older adults[13]. In their review, the PROT-AGE Study Group recommended an average daily intake of at least 1.0-1.2 g/kg body weight per day for people greater than 65 years of age to maintain and regain lean body mass and function[13]. Additionally, they recommended higher intakes (greater than 1.2 g/kg body weight per day) for those who are physically active. These increased intake targets are recommended due to the reduced ability to use available protein associated with advanced age, accompanied by an inadequate intake of protein, in order to prevent loss of function in older adults[13].

Sarcopenia

Sarcopenia, the loss of fat-free mass (FFM) during age-related muscle wasting, can compromise the functional abilities of the elderly[15,17]. BCAAs have been shown to attenuate muscle wasting[18], which is important in the prevention of sarcopenia[19]. Dietary leucine may attenuate age-related loss in muscle mass and strength, and leucine supplementation specifically may be important in preserving lean muscle mass during ageing[18].

Furthermore, emerging evidence suggests that the elderly specifically may benefit from distributing protein intake evenly throughout the day to promote an optimal per meal stimulation of MPS[15]. Leucine is thought to play a central role in mediating mRNA translation for MPS, and it is recommended that sufficient leucine is provided with dietary protein intake at each meal for the elderly population[15].

Muscle growth and maintenance

Dietary protein directly contributes to the maintenance of FFM, which requires different levels of protein across life stages and activity levels[20,21]. Maintaining skeletal muscle mass is important in conditions such as obesity, hyperlipidemia, cardiovascular disease (CVD), and type 2 diabetes because of the metabolic function of muscle in the body[22-26].

The ingestion of protein-containing meals results in stimulation of MPS[15]. In young adults (aged 18 to 30 years old), supplementation with a leucine-rich, high-quality protein can augment exercise-induced muscle mass development and lead to strength gains to a greater extent compared to other protein sources[15,21,27-28]. Additionally, supplementation with leucine-rich amino acid mixtures has been shown to improve strength and physical function and to increase muscle mass in the elderly[15,29]. When combined with exercise, protein ingestion helps to increase muscle synthesis, thus assisting in muscle protein accretion[15]. This increases muscle protein building response more than either stimulus alone[15].

Amino acid benefits of PrOatein™ Oat Protein

Leucine, isoleucine, and valine are BCAAs that are abundant in PrOatein™ Oat Protein and are known to influence MPS.

Protein consumption alone supports and maintains muscle mass; however, physical activity can increase the demands for protein consumption[4]. The indispensible BCAA leucine is a direct regulator of MPS through activation of the mTOR pathway, a cell signal known to stimulate muscle protein production[15,18]. Furthermore, the BCAAs leucine, isoleucine, and valine compose 14-18% of the total amino acids found in skeletal muscle protein and all of these amino acids are required for maintaining muscle health[18]. Leucine, along with isoleucine and valine, has been shown to stimulate MPS when administered in a protein-containing beverage in young men[30]. After exercise, the repeated ingestion of 20 g of high-quality protein containing leucine also has been shown to provide maximal muscle building stimulus during the recovery period[31].

Satiety and weight management

Obesity continues to be a major public health concern globally and may be improved through dietary protein consumption[4,32]. While energy balance is key to weight management, scientific research suggests that a diet rich in high-quality protein is one dietary strategy to aid in acute postprandial satiety and thus help with weight maintenance[14,20,25-26,33-35]. High protein diets have been successful at preserving lean body mass during weight loss[14,34,36], and diets using meal replacements that provide higher protein with moderate fat have been shown to assist in weight maintenance[37]. In the context of calorie reduction, a recent review found that a protein intake of 0.8-1.2 g/kg body weight per day is sufficient to sustain satiety, energy expenditure, and FFM independent of dietary carbohydrate content[20].

The protein content of the diet has long been recognised for its effect on food intake because high-protein diets may promote satiety and are associated with reduced calorie intake[14,25,35,38-41]. Protein can increase the postprandial perception of satiety as assessed by subjective measurements and stimulates the endocrine hormones in the gastrointestinal tract known to increase satiety[33,35,42]. Some research supports that a higher protein intake (25% of total energy) is effective for appetite control and satiety in overweight and obese men during hypocaloric-induced weight loss[43]. Additionally, recent research shows that when overweight and obese teen girls consumed a high-protein breakfast meal (35 g protein), there was a significant reduction in four-hour cravings for savory foods[40]. Also, it has been shown that consumption of an afternoon yoghurt snack (containing 14 g protein) versus crackers (containing 0 g protein) versus chocolate (containing 2 g protein) can increase the time to initiation of the next meal and decrease caloric intake in healthy women[41].

Gut hormones work collectively in response to meal consumption to help regulate food intake[44,45]. Appetite-suppressing hormones such as peptide YY (PYY) and glucagon-like peptide 1 (GLP-1) have been shown to be induced by dietary protein and are regulators of food intake[35,42,46]. Changes in short-term food intake have been shown to be directly modulated by PYY and GLP-1 in humans through signaling to the brain[46,47]. Cholecystokinin (CCK) is also an inhibitor of food intake and is released through postprandial stimulation by amino acids[42].

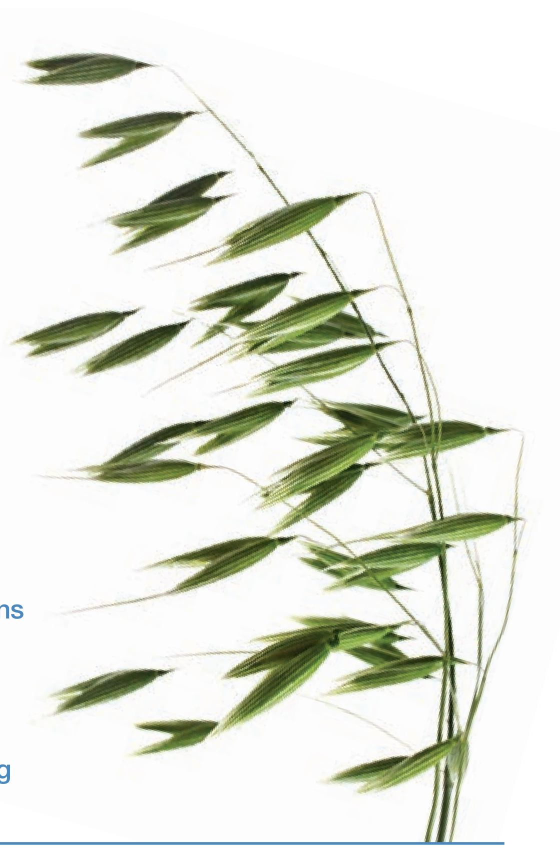
Animal studies have demonstrated that inhibition of food intake by high-protein meals occurs alongside the activation of nutrient-sensitive brain areas that contain specific neuronal cell types involved in satiety[48]. Furthermore, changes in perception of postprandial hunger, satiety, and food intake are positively associated with meals containing proteins in humans[43,49]. The ratio of macronutrients in a study of isocaloric meals demonstrated that a low carbohydrate/high protein diet (65.0% calories from protein, 17.2% calories from carbohydrate) significantly increased PYY and decreased hunger in humans when compared to a high-carbohydrate/low-protein diet (17.8% calories from protein and 64.5% calories from carbohydrates). This effect was seen in both lean and overweight individuals[33]. Although more research is needed in this area, increasing protein intake may be one way to help manage food intake and may help to maintain a healthy body weight through increased satiety.

Cardiovascular benefits

Research suggests the consumption of plant proteins may have protective effects against chronic diseases and may contribute to decreased circulating cholesterol levels[50-55]. Plant proteins are generally low in fat and can displace other dietary sources of protein that provide higher amounts of fat[20,55]. Furthermore, it is well known that diets high in fruits, whole grains, and vegetables are associated with a lower rate of CVD[20,51,56,57].

Prospective cohort studies support that high consumption of plant-based foods is also associated with a significantly lower risk of coronary artery disease and stroke[20,51]. Higher protein diets in general may improve blood pressure[51,57,58], triglyceride levels, and reduce adiposity according to a recent systematic review of 74 randomised clinical trials[34].

PrOatein™ Oat Protein Concentrate



- **In addition to its typical 55%* protein content, PrOatein™ Oat Protein contains:**
  - **o Typically 16-19% naturally occurring oat oil composed of:**
    - **Primarily palmitic, oleic, and linoleic fatty acids**
    - **A high concentration of monounsaturated fatty acids (oleic acid) and a high amount of polyunsaturated fatty acids (mainly omega-6)**
    - **Micronutrients with antioxidant properties, including vitamin E (tocopherols) and avenanthramides**
    - **No cholesterol, since this is a plant-based protein**
  - **o Naturally-occurring oat maltodextrins (approximately 20-24%)**
  - **o A small amount (2%) of oat beta-glucan soluble fibre**

- **PrOatein™ Oat Protein has a great taste compared to other isolated proteins**
- **PrOatein™ Oat Protein is a natural protein concentrate ingredient made from oats that can help meet the fast-growing consumer demand for protein-enriched foods and products containing oats**
- **PrOatein™ Oat Protein is vegan-friendly and may be suitable for gluten-free foods, depending on the recipe and the level of use, depending on local regulations**

Amino acid content

PrOatein™ Oat Protein is made from Swedish oats and is vegetarian- and vegan-friendly. PrOatein™ Oat Protein contains many of the amino acids needed for growth and development and has an abundance of leucine, isoleucine, and valine, the BCAAs known to be involved in muscle protein synthesis (Figure 2). As for oats in general, lysine is the limiting amino acid in oat protein. Combining oat protein with other plant proteins, such as pea protein, can create a more complete amino acid content in finished food products while still remaining vegetarian and vegan. When adjusting for a 91% protein digestibility (based on rolled oats[9]), the PDCAAS for PrOatein™ Oat Protein is 46%.

PrOatein™ Oat Protein has a great taste compared to other isolated proteins such as soy. PrOatein™ Oat Protein is a natural protein concentrate from oats that can help meet the fast-growing consumer demand for protein-enriched foods.

* PrOatein™ Oat Protein has a minimum 50% protein content specification, with a typical range of 52-56% protein content (on a dry matter basis).

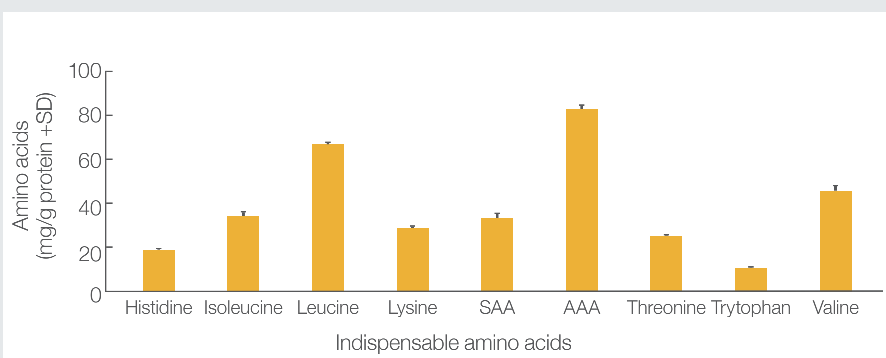
Use PrOatein™ Oat Protein in a wide range of foods and beverages

Oat-based products and protein-fortified foods are becoming increasingly popular in the marketplace. By using PrOatein™ Oat Protein, a wide-range of foods and beverages can provide the benefits of added protein that consumers desire while delivering the great taste that consumers expect.

PrOatein™ Oat Protein performs well in many food applications including bars, breakfast cereals and porridges, breads, cookies, smoothies, supplements, and sports nutrition beverages. With its mild cereal taste, PrOatein™ Oat Protein also makes a perfect base for bar fillings. PrOatein™ Oat Protein concentrate is a natural clean-label ingredient made from oats without the addition of chemicals or solvents.

Figure 2

Indispensable amino acid content of PrOatein™ Oat Protein[a]



[a]Average of six independently tested lots of PrOatein™ Oat Protein.

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Conclusions

Protein is an important part of the diet and plays an essential role in the structural and functional components of the body. PrOatein™ Oat Protein, like the oat grain it comes from, contains significant amounts of dietary indispensable amino acids, particularly the BCAAs leucine, isoleucine, and valine, which are important for muscle growth and repair in people of all ages. Oat protein contains more SAA and tryptophan than pea protein; SAA and valine than soy protein; and has more indispensable amino acids than wheat protein. PrOatein™ Oat Protein also has a great taste compared to other isolated plant proteins.

Ongoing research indicates that dietary proteins may induce satiety and could thus help with maintenance of body weight. Consequently, supplementing commonly-consumed foods with protein may help increase satiety and possibly decrease total energy intake.

A commitment to innovation

Tate & Lyle, a global leader in wellness innovation, is committed to delivering innovative ingredients that can be incorporated into great-tasting foods to help consumers meet their nutrition, health, and wellness needs every day. That is because Tate & Lyle invests heavily in innovation and research and in developing ingredients that can be incorporated into a wide variety of great-tasting food and beverage solutions. Teams of food and nutrition scientists are continuously innovating, researching, and testing ingredients that will meet current and future health and nutrition needs.

At the same time, Tate & Lyle has a robust market research program designed to provide the necessary insights on consumer preferences around the world. The research program allows Tate & Lyle to customise its offerings and provide tailor-made solutions in local and regional markets.

Better-for-you ingredients for health and wellness

In response to global public health efforts calling for people to reduce calories and sodium and increase fibre intakes, Tate & Lyle offers a number of innovative ingredient solutions that meet these needs.

To learn more about Tate & Lyle ingredients and innovation as well as health benefits and relevant research, please visit www.foodnutritionknowledge.info and www.tateandlyle.com.

Tate & Lyle's global Commercial and Food Innovation Center, Hoffman Estates, Illinois, USA

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