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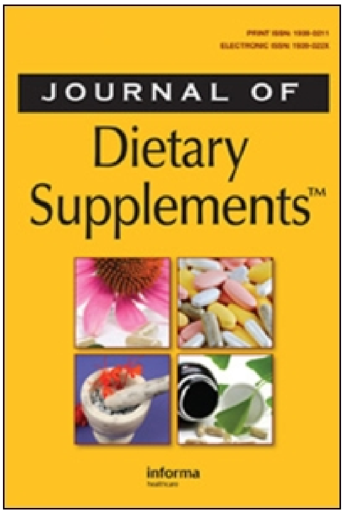

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Paula S. Stuart [a]; Stacey J. Bell [b]; Joseph Molnar [c]
[a] Medical Center Boulevard, Wake Forest University Baptist Medical Center, Winston-Salem, NC [b] Research and Development, Nutritional Sciences, Ideasphere Inc., Hauppauge, NY [c] Surgical Sciences, Department of Plastic and Reconstructive Surgery, Wake Forest University, Winston-Salem, NC

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Paula S. Stuart, MMS., RD, LDN
Stacey J. Bell, DSc, RD
Joseph Molnar, MD, PhD, FACS

ABSTRACT. Protein is essential for the maintenance of optimal health. Without adequate amounts of amino acids, organs become dysfunctional and ultimately death can result. Protein deficiency is a common problem in both adults and children. Numerous nutritional supplements have been developed to help optimize protein intake. The purpose of this paper is to describe the use of tryptophan-fortified hydrolyzed collagen for nutritional support in malnourished patients.

KEYWORDS. Protein quality, nutritional support, protein supplement, tryptophan-fortified hydrolyzed collagen, protein requirements

Paula S. Stuart is affiliated with the Wake Forest University Baptist Medical Center, Medical Center Boulevard, Winston-Salem, NC 27157.

Stacey J. Bell, formerly: Private Consultant, Belmont, Massachusetts Presently: Research and Development, Nutritional Sciences, Ideasphere Inc. Hauppauge, NY.

Joseph Molnar is affiliated with the Associate Professor, Surgical Sciences, Department of Plastic and Reconstructive Surgery, Wake Forest University, Bowman Gray School of Medicine, Winston-Salem, NC.

Address correspondence to: Paula S. Stuart, MMS., RD, LDN, Wake Forest University Baptist Medical Center, Medical Center Boulevard, Winston-Salem, NC 27157 (Email: pastuart@wfubmc.edu).

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INTRODUCTION

Protein is essential for maintaining optimal health. Individuals who do not consume adequate amounts of protein, or ingest amino acids in the correct balance, can develop organ dysfunction and ultimately death. Protein deficiency is a common problem in adults and children (Stephenson et al., 2000). Protein-energy malnutrition, also known as protein-calorie malnutrition, occurs when both protein and energy intake is insufficient to meet metabolic demands. Sometimes it occurs when individuals are unable to absorb essential nutrients for organ function. Protein-energy malnutrition was found in approximately forty-four percent or greater of hospitalized patients (Bistrian, 1976) and in another study, fifty percent of hospitalized patients (Mears, 1996).

In a recent study by Thomas et al., in 2002, prevalence of malnutrition was appraised in 837 patients admitted during 14 month period to a subacute-care facility. Twenty-nine percent of the patients were overtly malnourished and sixty-three percent were susceptible to malnutrition. Over one-half of these patients had low albumin concentrations, implying decreased visceral protein status. Twenty-five percent of the malnourished patients were re-admitted to an acute-care hospital compared to 11% of the well-nourished patients. Nelson and colleagues (1993) conducted a study in a long-term-care facility evaluating the prevalence of malnutrition in 100 patients 65 years or older. The prevalence of malnutrition was 39%. Forty-eight percent of these patients from Nelson and colleagues' study who were admitted from an acute-care facility were malnourished.

According to Beck and Rosenthal (2002), patients with chronic debilitating illnesses, patients who have not eaten for five days, and individuals who have prolonged nutrient losses are at risk for protein-calorie malnutrition. Additionally, they are susceptible to skin breakdown, suboptimal wound healing, and increased morbidity. In order to target this familiar and worrisome problem, various oral supplements and enteral formulas are available to help optimize protein and energy intake. The purpose of this paper is to investigate what characteristics comprise an ideal protein supplement and to evaluate the use of tryptophan-fortified hydrolyzed collagen for nutritional support.

THE BARRIERS TO PROTEIN CONSUMPTION

It has been a challenge to meet protein needs for certain populations. For those who are critically ill, due to hypermetabolic state, protein needs often exceed intake. Another population at risk is the aging. Millward (2004) suggests that population groups such as the sedentary elderly who require less energy may be in all likelihood in danger of protein malnutrition. He adds that increased amino acid density of nutritional regimens turn out to be more vital for the aging population. Furthermore, he states that increased physical movement and elevated dietary ingestion at energy balance may most likely decrease deficiency.

Although some patients may be able to take food by mouth, they may not be able to consume adequate protein due to frequent visits to the operating room or decreased appetite. Also, it may be impossible to consume adequate protein to meet metabolic demands if the patient feels full due to increased volume. Many individuals who are critically ill are intubated in an intensive care setting and are unable to take food by mouth. As a result, enteral nutrition may be necessary. Tube placement is often delayed due to surgical procedures or presence of an ileus and enteral feeding intolerance is common, ultimately decreasing optimal feeding time. For these reasons, it has become invaluable to health care professionals to find a product which provides the highest concentration of protein in the smallest volume.

USE OF ORAL SUPPLEMENTS

Oral supplements are a benefit to individuals whose nutritional demands outweigh nutritional intake. These may help an individual maintain or promote lean body mass and thereby improve overall nutritional status. Johnson and colleagues (1993) conducted a case-control study exploring the indications for nutritional supplements and the usefulness of supplementation of elderly patients living in a nursing home. These patients were given nutritional supplements because of decreased appetite (16%) and weight loss (71%). All participants were under ideal body weight upon admission and continued to lose weight until oral supplementation was begun. Weight gradually increased over approximately ten months.

Additionally, research has indicated that oral supplements improve wound healing in patients. In a study by Breslow et al. (1993), twenty-eight malnourished patients with a total of 33 truncal pressure ulcers received liquid nutritional formulas as enteral feedings or meal supplements having either 24% or 14% of the energy from protein for 8 weeks. Total truncal pressure ulcer surface area decreased in the 15 patients in the higher protein group but not those in the lower 14% protein group. The change in total ulcer area correlated with both dietary protein intake per kg body weight and caloric intake per kg body weight. The decrease in stage IV ulcer area in eight patients in the higher protein group was significantly greater than in eight patients in the lower protein group. In these 16 patients, the decrease in ulcer size also correlated with dietary protein intake per kg body weight.

PROTEIN AND WOUND HEALING

Oral supplements may have an important role in the healing process with patients with large wounds or burns because those who are malnourished can have impaired wound healing because wound healing depends upon adequate intakes of calories, protein, vitamins and minerals. Malnutrition retards the healing process (Barbul & Purtill, 1994). Several studies have shown that protein-calorie malnutrition of a short amount of time can result in impaired wound healing (Meyer, Muller, & Herndon, 1994; Levenson & Seifter, 1977; Greenhalgh & Gamelli, 1987; Haydock & Hill, 1986). Super normal protein intakes are often required for collagen formation, enzyme activity, and cell replication. (Breslow et al., 1993; Chernoff, Milton, & Lipschitz, 1990).

It makes sense that amino acid requirements are ultimately affected by diseased state. The amino acid requirement during stress is controversial. According to Furst and Stehle (2004), no conclusive data exists that determines changes of amino acid requirements brought about by occurrence of sepsis, trauma or injury, diabetes, renal or liver failure. Furst and Stehle, nevertheless, notes that diseases resulting in wasting are indeed associated with amino acid deficiencies resulting in specific changes in amino acid requirements (2004).

Soeters et al. (2004) report that certain amino acids have an important impact during stress. Cysteine, for example, may help maintain the redox state during active disease. They also note that glycine may be anti-inflammatory, immunomodulatory, and cytoprotective agent during illness. Additionally, they suggest that BCAA may become undersupplied in severely ill patients. Histidine may be lacking during renal failure. Soeters and colleagues note that during stress increased protein synthesis in areas such as liver, immune system, wounds is first priority. They do state that the substrate mix is different from the nondiseased state or starvation in healthy humans. Glutamine and alanine are produced in excess during disease or stressed conditions. They do state that there does not appear to be a straightforward advantageous effect of arginine supplementation in critically ill patients but note that there is a dilemma in the changeability of patient populations and complexity in quantitatively evaluating endpoints such as wound healing or immune response.

Selected amino acids, arginine, and glutamine, may promote wound healing, and are conditionally essential in certain situations. Arginine and glutamine supplementation augments collagen synthesis in healthy elderly volunteers and is a safe way of speeding up wound repair (Williams, Abumrad, & Barbul, 2002). Williams et al., found that collagen synthesis was enhanced in healthy aging patients when given supplemental arginine, HMB (Beta Hydroxy-Methyburate), and glutamine (2002).

Arginine is a conditionally essential amino acid during trauma, burn injury, small-bowel resection, and renal failure because of its capacity to correct endothelial dysfunction, improve wound healing, deter tumorigenesis, and enhance immune function (Flynn, Meininger, Haynes, & Wu, 2002). Under these conditions, the body is unable to make the extra arginine required. It has been shown to improve collagen synthesis and pituitary growth hormone secretion (Barbul et al., 1983; Barbul et al., 1985; Barbul et al., 1990). This amino acid may be particularly beneficial for wound healing because it is the only substrate for nitric oxide production (Kirk, Hurson, Regan et al. (1993); Witte, Thornton, Tantry, & Barbul (2002)). Arginine also helped restore nitric oxide levels to a near-normal level and drastically increased wound breaking strength in rats who received a skin incision, infused with 1 g/kg arginine twice daily.

Benati, Delvecchio, and Cilla et al. (2001) studied thirty-six hospitalized patients with severe cognitive impairment and pressure sores who were given regular diet, a regular diet plus a high protein, high calorie supplement, or the same supplement enriched with 7.5 g arginine, 25 mg zinc and antioxidants in 2 servings for two weeks. The patients drinking high calorie, high protein supplements had a more rapid improvement in pressure ulcer healing than those patients without an oral supplement. Interestingly, the greatest healing was witnessed in the group given arginine, zinc, and antioxidants.

An oral dose of 30 g arginine per day appears to be a safe for the promotion of wound healing and stimulation of immune response and may benefit patients at risk of infection (Barbul et al., 1981; Flynn et al., 2002). Williams, Abumrad, & Barbul (2002) note that supplemental arginine is tolerated well over short periods of time, and Barbul et al. (1981) found that provision of 30 g of arginine per day for at least 3 days was well tolerated.

Glutamine is a source of energy for immunocytes thereby optimizing gut mucosal repair (Smith & Wilmore, 1990). It also safeguards function of immune cells, serving as a primary fuel source for lymphocytes, macrophages, neutrophils, and natural killer cells (Krebs H. 1980). It aids protein synthesis and has been shown to reduce hospital duration. Most studies show an advantage of 0.6 gram/kg or less of glutamine per day. It should be used with caution in those with liver or kidney failure, leading to excess ammonia production in these patients.

PROTEIN AND THE STRESSED PATIENT

The critically ill who have sustained traumatic injuries have increased protein needs because of alterations in digestion and metabolism. Trauma often results in hypermetabolism, in which the lean body mass (muscle stores, collagen, and visceral protein) is rapidly depleted (Hart et al., 2000). Adequate nutritional support can slow protein catabolism (Cerra, 1996)

Soeters and colleagues (2004) indicate that trauma patients have increased protein turnover, and during critical illness there is compromised digestion. Because of this, these patients may need alterations in food quantity and how dietary protein is given. Human metabolism during illness is directed towards the healing process rather than preserving muscle mass, which can change amino acid requirements.

During stress, protein synthesis does not exceed protein catabolism, resulting in an increase in excretion of urinary nitrogen. Glucocorticoids hasten the movement of amino acids from the skeletal muscle to the liver (Chiolero, Revelly, & Tappy, 1997). The body uses carbon atoms from the amino acids as energy substrates, and the nitrogen moieties are lost in the urine (Cerra, 1996). Urinary nitrogen approximates 30 grams per day, reflecting increased skeletal muscle and visceral protein wasting (Chang & Peck, 2001). Additionally, hyperglycemia after a traumatic injury may affect amino acid requirements (Furst & Stehle, 2004).

It has been suggested that during critical illness protein requirements can increase up to 1.5–2.0 g/kg body weight (Flancbaum et al., 1999). The weight for this equation is the actual body weight or weight prior to illness (Trujillo & Robinson, 1999). Suggested of protein intake (g/kg body weight) for various diseased states are listed in Table 1.

PROTEIN AND AMINO ACID REQUIREMENTS

When considering the needs of patients potentially needing oral supplementation, it is important to consider their particular protein and amino acid requirements, as well as the protein composition of the particular products under consideration, including protein quality.

TABLE 1. Suggestions of Protein Intake for Certain Diseased States

Disease State	Protein (g/kg)
Pressure Ulcers	
Stage	
Stage I	1.0–1.1
Stage II	1.2
Stage III	1.3–1.4
Stage IV	1.5–1.6
Burns	
%TBSA	
Less than 20% TBSA	1.5–1.8
Greater than 20% TBSA	2.0–2.5
Sepsis	1.5–2.0
Trauma	1.5–2.0
Acute Renal Failure	0.6–0.8
Chronic Renal Failure (CFR < 25 mL/min)	0.6
Hemodialysis	1.2–1.5
Peritoneal Dialysis	1.3
Renal Transplant	1.5
Nephrotic Syndrome	0.8
Liver Disease	1.5
Liver Failure with Encephalopathy	0.5–0.7 increased to 1.0–1.5 as tolerated.

Proteins vary according to their origin, amino acid composition, and digestibility. Animal products such as poultry, meat, eggs, cheese, milk, and fish contain all nine essential amino acids and are regarded as having a high biological value (Mahan & Escott-Stump, 1996). Humans require essential amino acids because they cannot be synthesized by the body. Plants, such as nuts, legumes, vegetables, and grains, have lower biological values, because they do not contain all nine essential amino acids (Mahan & Escott-Stump, 1996). Such foods must be combined with other protein sources, such as a peanut butter, to yield a complete amino acid profile. (Wardlaw & Insel, 1993) Soeters and colleagues (2004) suggest that amino acid adequacy does not just depend on amino acid composition and digestibility of a specific protein food but on the quality and quantity of the entire meal as well. Table 2 illustrates dispensable, indispensable, and conditionally indispensable amino acids

Amino acid requirements are affected by metabolic need which is influenced by stage of development, reproductive state, environmental factors, and diseased state (Furst & Stehle, 2004). Amino acid requirement needed

TABLE 2. Dispensable, Indispensable, and Conditionally Indispensable Amino Acids

Indispensable	Dispensable	Conditionally Indispensable
Histidine	Alanine	Arginine
Isoleucine	Aspartic Acid	Cysteine
Leucine	Asparagine	Glutamine
Lysine	Glutamic Acid	Glycine
Methionine	Serine	Proline
Phenylalanine		Tyrosine
Threonine		
Tryptophan		
Valine		

Source: Dietary Reference Intakes for Energy, Carbohydrate, Fiber, Fat, Fatty Acids, Cholesterol, Protein, and Amino Acids, 2002.

to sustain metabolic demands will be affected by digestibility and amino acid pattern of the dietary protein (Furst & Stehle, 2004).

Protein and amino acid requirements have been studied for over a century. Rose et al., first determined the daily essential amino acid requirements of humans in 1946 (Table 2). According to Furst and Stehle (2004) Rose defined the essential amino acid requirement as the highest amino acid requirement needed to achieve a positive nitrogen balance. The FAO/WHO considered Rose's standards for determining amino acid requirements in 1973 and 1985.

According to Furst and Stehl (2004), low amino acid requirements were disapproved of by many scientists. As a result new methods of assessing amino acid requirements were considered resulting in an approach based upon availability of amino acids labeled with stable isotopes. These new methods suggested that essential amino acids requirements were actually higher than the nitrogen balance method previously used.

In 1980, the Food and Nutrition Board of the National Research Council set standards for amino acid intakes based on age groups. In 1985, Food and Agriculture Organization (FAO) of the United Nations estimated amino acid requirements based upon nitrogen balance studies, growth, and serum amino acid levels. The FAO defined protein requirement as "the lowest level of dietary protein intake that will balance the losses of nitrogen from the body in persons maintaining energy balance at modest levels of physical activity." (1981). In 1989 FAO/WHO determined that the essential amino acid requirements for adults should be equal to preschool children because

TABLE 3. Daily Requirements of Amino Acids

Amino Acid	Minimum Amount	Recommended Amount
Isoleucine	0.70	1.40
Leucine	1.10	2.20
Lysine	0.80	1.60
Methionine	1.10	2.20
Phenylalanine	1.10	2.20
Threonine	0.50	1.00
Tryptophan	0.25	0.50
Valine	0.80	1.60
TOTAL	6.35 g	12.70 g

Source: W.C. Rose, The amino acid requirements of adult man.

after 2 years of age the quantitative requirement for growth is negligible compared with body maintenance (Furst & Stehl, 2004). The requirements for indispensable amino acids have not been published for FAO/WHO committee in 2001.

The most recent recommended values for protein and amino acids (Tables 3 and 4) are provided.

TABLE 4. Dietary Reference Intake of Indispensable Amino Acids

Amino Acid	Mg/g protein
Histidine	18
Isoleucine	25
Lysine	55
Leucine	51
Methionine and Cysteine	25
Phenylalanine and Tyrosine	47
Threonine	27
Tryptophan	7
Valine	32

Source: Dietary Reference Intakes for Energy, Carbohydrate, Fiber, Fat, Fatty Acids, Cholesterol, Protein, and Amino Acids, 2002.

PROTEIN QUALITY

High quality proteins are easily digested by the body. The structure of the protein influences digestibility. Some, such as glycosylated proteins, are resistant to intestinal enzymes and are poorly digested. Since 1919, assessing protein quality was done by the Protein Efficiency Ratio (PER). (Pellett & Young, 1980). The PER has been used in the United States and Canada for regulating food labeling and for establishing RDA (Wardlaw & Insel, 1993). A PER is determined in young, growing rats fed a measured amount of protein and weighed periodically. PER equals weight gain (g) / protein intake (g). Values range from one to zero. A rate of one indicates 100 percent utilization of dietary amino acids, and zero indicating no consumption. Eggs, milk and cheese, meat and fish, peanut butter, and refined wheat have the highest utilization of all proteins. (Pellett & Young, 1980).

Net Protein Utilization (NPU) was defined as the ratio of amino acids converted to protein to the ratio of amino acids supplied. NPU is affected by the level of limiting amino acids within a food and is measured protein as nitrogen excretion. NPU $=$ (0.16 $\times$ 24 hour protein intake in grams) – (24 hour urinary urea nitrogen $+$ 2) $-$ (0.1 $\times$ ideal body weight in kilograms) / (0.16 $\times$ 24 hour protein intake in grams). Values range from 1 to 0, a value of 1 indicates 100% utilization of dietary nitrogen as protein. Value of 0 indicates none of the nitrogen supplied was converted to protein. Eggs or milk have an NPU of one (Bodwell et al., 1989).

In 1993, the U.S. Food and Drug Administration (FDA) decided to utilize the Protein Digestibility Corrected Amino Acid Score (PDCAAS) instead of PER in food labeling (Schaafsma, 2000). The PDCAAS was considered to be the best method of evaluating protein quality because it is based on human needs rather than animals as the PER do. The PDCAAS is presently used for labeling protein on food products. PDCAAS is apparently calculated based on human amino acid requirements instead of the amino acid needs of animals. (Sarwar & McDonough, 1990).

Enzymatically predigested proteins help increase their digestibility (Mahan & Escott-Stump, 1996). Patients with decreased absorption and compromised gut mucosal function and increased permeability may benefit from predigested protein. Amino acids are more readily available than intact protein is in this form. A fruit enzyme such as papain can be used to predigest protein thus rendering it easier for absorption or digestion. (Mahan & Escott-Stump, 1996).

COLLAGEN: STRUCTURE AND FUNCTION

Collagen is an insoluble, extracellular glycoprotein found in all animals. It is the most abundant protein in the human body and is an critical structural component of all connective tissues in the body, including bone, tendons, cartilage, ligaments, and skin. It is made up of over 3000 amino acids that are intertwined and cross-linked, providing structural integrity to tissues in the body. (Murray, Granner, Mayes, Rodwell, 2002) Collagen has been utilized commercially for enhancing the nutrition of foods.

There are at least nineteen different types of collagens which have been found in humans and reported in literature. Types I through V are the chief ones. Type I is the most abundant collagen, the principal element of ligaments, tendons, skin, and bones, sclera, dentin, fibrous cartilage, and organ capsules. Type II characterizes more than 50% of the protein in cartilage. Type III supports the walls of hollow areas such as the fetal skin, intestinal tract, uterus, and blood vessels. Type IV collagens provide the filter for the blood capillary system as well as the glomeruli of kidneys and lens capsule. Type V is found in the basement laminae of blood vessels and smooth muscle cells, and exoskeleton of fibroblasts and other mesenchymal cells. The types are important but are less plentiful. (Murray, Granner, Mayes, Rodwell, 2002).

Collagen has a triple helical structure in which each polypeptide subunit is twisted into a left-handed helix of 3 residues for every turn. Three of the alpha chains are then twisted into a right-handed elongated super helix, resembling a rod. The distinguishing feature of collagen is the frequency of glycine residues at every third position of the triple helical segment of the alpha chain. Interestingly, glycine is the only amino acid that is small enough to fit in the restricted space accessible down the central core of the triple helix. Many of the remaining chains are filled by proline or hydroxyproline. (Murray, Granner, Mayes, Rodwell, 2002). Proline and hydroxyproline give stiffness to the collagen molecule. Hydroxyproline is created by the posttranslational hydroxylation of peptide-bound proline residues which are catalyzed by the enzyme prolyl hydroxylase, whose cofactors are iron, ascorbic acid and α-ketoglutarate. (Murray, Granner, Mayes, Rodwell, 2002).

Collagen is fundamental for every step of wound healing. It has an essential role in blood clotting before the healing process can occur by increasing platelet concentration, making platelets sticky, and triggering platelet activation. Additionally, it hosts cells such as macrophages which regulate the entire healing process and provides an environment for cells to actively form new tissue. Importantly, collagen gives strength to new tissue over time. Furthermore, collagen absorbs fluid and fills spaces in the wound which otherwise may be an area for infection. (Raher, 1999).

AN OPTIMAL PROTEIN SUPPLEMENT

When looking for a high quality nutritional product, one must consider digestibility, concentration of nutrients per volume, and ease of delivery as well as the quality of the nutrients. An optimal product would contain high quality ingredients, increased nutrients in a smaller volume, would be easily digestible, and would be easy to give to a patient by a caregiver. A tryptophan-fortified liquid hydrolyzed collagen supplement meets all of these important criteria. It is particularly beneficial to patients in long-term care facilities and hospitals suffering from PEM and PCM.

Standard hydrolyzed collagen is not a perfect amino acid according to the established standards because it does not contain the amino acid tryptophan. A tryptophan-fortified liquid hydrolyzed collagen supplement is, in fact, considered a complete protein. Forms of hydrolyzed collagen have been utilized for several decades as a dietary supplement. Collagen hydrolysate has been of interest as a potential therapeutic agent in the treatment of osteoarthritis and osteoporosis (Moskowitz, 2000). Closer investigation of this product will reveal that it may indeed meet the protein requirements of a malnourished individual, containing an optimal amino acid composition, high bioavailability, and high digestibility.

Tryptophan-fortified hydrolyzed collagen contains glycine, arginine, proline, and hydroxyproline which have been found to be beneficial under certain conditions (Soeters et al., 2004; Williams, Abumrad, & Barbul, 2002). In fact, 1/3 of the collagen molecule is glycine and ¼ is proline or hydroxyproline. Since patients consume mixed diets with proteins from variety of sources, they should not have a problem meeting their complete amino acid requirements when using this product.

In a study by Blackburn et al., when tryptophan-fortified hydrolyzed collagen was utilized as a sole source of exogenous protein and calories, a nitrogen balance was achieved. Notwithstanding tryptophan-fortified hydrolyzed collagen should ideally be used as a supplemental protein and not as the sole source of calories.

Because of its high nitrogen content, tryptophan-fortified hydrolyzed collagen provides high NPU, which is the ratio of amino acid converted to proteins to the ratio of amino acids supplied (Pellett & Young, 1980). Tryptophan-fortified hydrolyzed collagen contains 15 grams of protein per 30 ml serving which is a significant amount in a very small volume. A

TABLE 5. Recommended Dietary Allowances for Adults of Indispensable Amino Acids

Amino Acid	19 years and older (mg/kg/day)	Pregnancy (mg/kg/day)	Lactation (mg/kg/day)
Histidine	14	18	19
Isoleucine	19	25	30
Leucine	42	56	62
Lysine	38	51	52
Methionine + Cysteine	19	25	26
Phenylalanine + Tyrosine	33	44	51
Threonine	20	26	30
Tryptophan	5	7	9
Valine	24	31	35

Source: Recommended Dietary Allowances from Dietary Reference Intakes for Energy, Carbohydrates, Fiber, Fat, Protein, and Amino Acids (Macronutrients), 2002.

mere three to four ounces of this product per day would closely meet the RDA for protein. In addition the product contains significant amounts of arginine, glycine, proline, and hydroxyproline which have been shown to optimize wound healing and help preserve lean body mass.

Tryptophan-fortified hydrolyzed collagen is available in a liquid form, so that it will not have to be mixed to be consumed. The product is shelf-stable and no refrigeration is necessary. This aspect is important in nursing homes and other health care facilities, where diets of modified consistency are offered on a regular basis and oral supplements often sit at the patient's bedside throughout the day. Clumping associated with powder protein supplements has been problematic in the past, especially when adding them to enteral feeds. This product can be added to enteral feeds easily, as well cold and hot beverages, and cereals. In addition, hydrolyzed protein does not contain fat, which would be beneficial for patients with malabsorption issues.

Table 6 compares suggested indispensable amino acid intakes for children ages 2-5 and amino acid profile of tryptophan-fortified hydrolyzed collagen. Table 7 reveals the complete amino acid profile of tryptophan-fortified hydrolyzed collagen. As one can visualize from the amino acid profile, this product contains high-nitrogen amino acids—Arginine, Glycine, Proline, and Hydroxyproline that support tissue healing and help protect lean body mass stores. In a hydrolyzed form, these amino acids are available for maximum digestion and utilization by the body.

TABLE 6. Amino Acid Requirements for Humans as Compared to Hydrolyzed Collagen Product

Essential Amino Acid	Children[1] (2-5 yrs)	Hydrolyzed Collagen mg/g protein
Arginine	—	85
Histidine	19	7.4
Isoleucine	28	17
Leucine	66	31
Lysine	58	45
Methionine and cystine	25	8.7
Phenylalanine and tyrosine	63	24
Threonine	34	22
Tryptophan	11	4.4
Valine	35	26

[1] FAO/WHO/UNU, 1985.

TABLE 7. Amino Acid Profile of Tryptophan-Fortified Hydrolyzed Collagen (g/100 g protein)

Essential Amino Acids		Non-Essential Amino Acids	
Histidine	0.74	Alanine	9.30
Isoleucine	1.70	Arginine	8.55
Leucine	3.10	Aspartic Acid	6.60
Lysine	4.50	Cystine	0.07
Methionine	0.80	Glutamic Acid	11.10
Phenylalanine	2.20	Glycine	26.90
Threonine	2.20	Proline	14.80
Tryptophan	0.44	Serine	3.20
Valine	2.60	Tyrosine	0.20
MODIFIED AMINO ACIDS			
Hydroxylysine	0.91		
Hydroxyproline	14.00		

CONCLUSION

In endemic environments for protein malnutrition such as hospitals, long-term health care facilities, and aging populations, oral supplements are beneficial for optimizing protein intake. Considering the quality of the nutrients, digestibility, concentration of nutrients per volume, and ease of delivery, a tryptophan-fortified hydrolyzed collagen is an appropriate product for use as a protein supplement. Because this product is a "complete" protein, it would be very beneficial for patients who either are not taking in enough protein in their diet or have increased protein needs due to certain diseased states, especially wounds. The fact that this product contains glycine, arginine, glutamine, and proline makes the product even more valuable, since these amino acids are thought to be beneficial for wound healing.

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