

Understanding the Protein Digestibility Corrected Amino Acid Score (PDCAAS)

Nancy Collins, PhD, RD, LD/N, FAPWCA

Protein, defined as a complex nitrogenous compound made up of amino acids in peptide linkages, is essential for life. Proteins carry out the work of the cell by serving as enzymes, receptors, transporters, hormones, antibodies, or communicators that build, maintain, and repair body tissues.

Wound care professionals and registered dietitians (RDs) understand that patients often require increased amounts of protein for healing. Protein is a hot topic today. This has resulted in a proliferation of new products on the market, such as whole proteins, partially hydrolyzed proteins, or targeted amino acids, all available in a variety of forms and flavors, including powders, liquids, and even chicken soup. The challenge is deciding what type of protein is best.

Amino Acids Classification

A polypeptide chain is comprised of three categories of amino acids. Indispensable amino acids (IAAs), also known as essential amino acids, are not synthesized by humans and must come from the diet. Dispensable amino acids (DAA), also known as nonessential amino acids, are produced by the body in sufficient amounts under normal, healthy conditions. Conditionally indispensable amino acids (CIAA) are produced in sufficient amounts by healthy individuals. However, in the presence of certain disease states or underlying physiological stress such as nonhealing wounds, supplementation often is required to achieve an adequate supply of CIAAs. Table 1 lists the amino acids that fall into each category.¹

Systems of Evaluating Protein

Protein assessment has evolved through the years. Some of the past methods included protein efficiency ratio (PER), biological value (BV), and net protein utilization (NPU). Although each of these grading systems used different inputs, they all sought to rate the utilization and digestibility of protein and amino acids.

In 1991, the Food and Agriculture Organization/World Health Organization² (FAO/WHO) proposed a new system, which subsequently was adopted by the Food and Nutrition Board of the Institute of Medicine. This method, the protein digestibility corrected amino acid score (PDCAAS), is determined by comparing the amino acid profile of the food in question against a standard amino acid profile, with 100 as the

Table 1. Classification of amino acids¹

Indispensable Amino Acids (Essential AA)	Role in Wound Healing	Conditionally Indispensable Amino Acids
Histidine	Alanine	Arginine
Isoleucine	Aspartic acid	Cysteine
Leucine	Asparagine	Glutamine
Lysine	Arginine	Glycine
Methionine	Cysteine	Proline
Phenylalanine	Glutamic acid	Tyrosine
Threonine	Glutamine	
Tryptophan	Glycine	
Valine	Proline	
	Serine	
	Tyrosine	

highest possible score. Scores above 100 are not allowed and are truncated to 100.² Figure 1 shows the PDCAAS formula.

The purpose of the PDCAAS is to rate the overall quality of a protein based on the amount of IAAs contained therein. The score is based on the amino acid that is in the shortest supply when compared to a reference (scoring) pattern. This scoring pattern is based on the IAA requirements of preschool-age children. Digestibility of the protein also is factored into the score by way of fecal digestibility. For example, common digestibility percentages include 98% for egg protein; 95% for casein, soy, and collagen; and 91% for wheat protein. This system, although criticized,^{3,4} is widely used today.

PDCAAS in Action

If a protein is completely missing just one IAA, the PDCAAS is 0. If a protein with a low amount of one IAA has a PDCAAS of 20, we would say that the protein provides only 20% of that particular amino acid when compared to the scoring pattern; so, in theory, only 20% of this protein is possibly available for protein synthesis in the human body. In other words, to meet the IAA requirement for the day, without a source of any other protein in the diet, a person would need to consume five times the quantity of the protein with a PDCAAS of 20 than for one with a PDCAAS of 100. Proteins that have a PDCAAS of 100 contain all of the

This article was not subject to the Ostomy Wound Management peer-review process. Nancy Collins, PhD, RD, LD/N, FAPWCA, is founder and executive director of RD411.com and Wounds411.com. For the past 20 years, she has served as a consultant to healthcare institutions and as a medico-legal expert to law firms involved in healthcare litigation. Correspondence may be sent to Dr. Collins at NCtheRD@aol.com.

Figure 1. The PDCAAS formula.

$$\text{PDCAAS, \%} = \frac{(\text{mg of first limiting amino acid in 1 g test protein})}{(\text{mg of the same amino acid in 1 g reference protein})} \times \text{TD}^* (\%) \times 100$$

*TD = true fecal digestibility of the test protein, as measured in a rat assay

IAs in the right amount for protein synthesis by humans (eg, egg white, whey, casein, and soy).

Criticism of PDCAAS

All methods of protein evaluation have pros and cons. The scientific community's criticism of PDCAAS largely revolves around three main points. The first argument addresses the maximum score of 100. Proteins with specific IAs that go beyond the scoring pattern are still scored at 100. This truncation does not allow for the fact that what another protein lacks, one that scores above 100 might make up for. This is the case in a diet that provides protein from a variety of sources. In other words, limiting the score to 100 is only applicable to a diet that contains solely that one particular source of protein.

The second consideration is the use of a scoring pattern that is based on the IA requirements of preschool children. The reference scoring pattern was based on amino-acid balance studies performed more than 25 years ago on a limited number of 2-year-old children recovering from malnutrition.² The validity of the scoring pattern is not established. In addition, the scoring pattern does not take into account CIAs, which also contribute to the nutritional value of a protein. Arginine and glutamine are two CIAs with roles in wound healing; this point is often of interest to wound care practitioners.

Thirdly, use of fecal rather than ileal digestibility is problematic for some scientists. The use of fecal digestibility overestimates the nutritional value of a protein because amino acid nitrogen entering the colon is lost for protein synthesis in the body and is, at least in part, excreted in urine as ammonia.²

Practice Points

Clinicians should keep in mind that the PDCAAS score is academic and mathematical in nature. Perhaps the best applicability of PDCAAS for practicing clinicians is to consider the PDCAAS of the overall diet. In virtually all cases, patients are not consuming only a single source of protein. They are consuming meals, meals plus supplements, tube feedings, or a combination of these. When you look at the overall intake of amino acids in the total daily diet, the PDCAAS is usually 100.

It is necessary to take into account many other considerations beyond any system of protein evaluation when prescribing additional protein for a patient. The most relevant factor is patient acceptability and consumption. Foods and supplements may have the highest score attainable, but they will not do any good if they are returned on the meal tray or poured down the drain, as is the case with many liquid supplements. High-protein supplements are available in many flavors; it is important to give patients a choice of their preferred flavors whenever possible.

Many elderly patients have poor appetites and diminished digestive ability. In long-term care, frail and infirm patients often eat very little of the meal. In these situations, portion size becomes increasingly important. Protein supplements are available that provide 15 g of protein in a 1 fl oz portion. For patients with poor food consumption, such a supplement sometimes is easier to swallow than one that requires an 8 fl oz serving. This is also a concern in patients who are volume restricted because of medical problems, such as renal disease or congestive heart failure.

An additional selection criterion is the supplement's digestibility. This is similar to simply wasting time and money on products that are not consumed because some patients are unable to digest certain products and therefore require predigested proteins. Protein metabolism depends on proper digestion where whole protein is hydrolyzed into amino acids. If a patient has poor digestive capacity, provision of a predigested product is the best choice. Targeted amino acids, namely arginine and glutamine, are also widely available for patients who may benefit from specific amino acid therapy.

Protein supplementation is provided in many forms, including traditional canned or bottled beverages, concentrated liquids, and powders. Products are available in individual packs, bulk containers, or bottles and require different amounts of preparation to dispense to patients. Staff effort to prepare the supplement is yet another consideration. If staff do not have time to measure, mix, prepare, store, and serve the supplement properly, regulatory issues may arise, as well as taste and acceptance problems.

Although protein evaluation scores are vitally important to researchers, academicians, and food scientists, healthcare practitioners may find they are better served by viewing the bigger picture of which the PDCAAS score is only one part. Patient acceptance, flavor, form, volume, digestibility, ease of preparation, and cost all play a role in protein selection. Having a variety of products available will help meet all patients' needs and preferences in this era of individualized care. ■

References

1. Castellanos VH, Litchford MD, Campbell WW. Modular protein supplements and their application to long-term care. *Nutr Clin Pract*. 2006;21(5):485–504.
2. Schaafsma G. The protein digestibility-corrected amino acid score. *J Nutr*. 2000;130(7):1865S–1867S.
3. National Academy of Sciences, Institute of Medicine, Food and Nutrition Board. Protein and amino acids. In: *Dietary Reference Intakes for Energy, Carbohydrate, Fiber, Fat, Fatty Acids, Cholesterol, Protein, and Amino Acids*: Food and Nutrition Board: National Academy of Sciences. Washington, DC: National Academy Press;2005.
4. FAO/WHO Expert Consultation. Protein Quality Evaluation: Food and Agriculture Organization of the United Nations, FAO Food and Nutrition Paper No. 51. Rome, Italy: Food and Agriculture Organization;1991.