Digestive Enzymes 101

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WHAT ARE ENZYMES?

Enzymes are proteins that act as biochemical catalysts to control the rate of nearly all chemical reactions in living cells. Every living organism on Earth produces enzymes to break down food sources and metabolic wastes as well as to build structural and functional compounds necessary for growth. The human body produces thousands of different enzymes to build, repair and maintain itself. In your body, there are thousands of enzymes directing the processes in the billions of cells that make up your body. Enzymes make it possible for you to see, read and understand this paper.

Enzymes are such a critical part of a healthy functioning body that many genetic disorders are the result of inefficient, deficient or absent enzymes. Other dysfunctions may occur when enzyme systems become imbalanced. The benefits of many vitamins and minerals are due to their ability to affect the activity of various enzymes. These nutrients often act as cofactors and coenzymes that activate or increase the functionality of enzymes. Enzymes are vital for our daily health and wellness.

Each enzyme will only catalyze a certain type of reaction. For example, proteases will only catalyze the breakdown of proteins and will not react with carbohydrates or fats. The ability of an enzyme to interact with its substrate is attributed to the conformational structure of the enzyme’s active site. Simply stated, the active site of a protease will “fit” with the shape of proteins where it does not “fit” with a carbohydrate or fat. Additionally, optimal enzyme structure and function can also be impacted by temperature, pH and other environmental factors in the cell.

WHAT ARE DIGESTIVE ENZYMES?

This group of enzymes breaks down the foods we eat into their simplest components so that they can be absorbed and utilized by the body. The human body is known to produce at least 22 different digestive enzymes. Salivary amylase begins the digestion of carbohydrates as soon as we start chewing with other enzymes secreted by the pancreas and intestinal brush border membrane helping to complete their digestion. Lipases secreted in the mouth and stomach start the digestion of fats and oils. Fat digestion is finished in the small intestine by additional lipases and esterases. Protein digestion begins in the acidity of the stomach with the action of pepsin and is completed in the small intestine by pancreatic proteases and the brush border aminopeptidases. Figure One offers a graphic illustration of where digestion occurs for each of the major types of food macromolecules.
WHY SUPPLEMENT WITH DIGESTIVE ENZYMES?

A common objection to the supplementation of enzymes is the belief that the human body is capable of producing all the digestive enzymes it needs. Yet this may not be the case for everyone. Unfortunately, digestive enzyme shortages can and do occur in the human body. Lactase deficiency is the best known example, occurring in as much as 70% of the world's adult population. Aging also impacts the body's ability to produce digestive enzymes with some estimates as high as a 50% loss of digestive activity.

Research has also begun to identify the role that the intestinal microflora can play in digestion. These microorganisms can supply additional or unique digestive enzymes, providing you have the appropriate intestinal denizens. As an example, most individuals in the Orient have gut flora that produce the enzyme beta-glucosidase. This enzyme removes the sugar unit off of soy isoflavones and allows their absorption. In contrast, most other human beings lack these intestinal bacteria and the activity of beta-glucosidase causing poor absorption of soy isoflavones. Supplemental forms of beta-glucosidase along with soy foods may support improved absorption by cleaving the sugar unit off soy isoflavones. Other enzymes including lactase and alpha-galactosidase are also produced by different microorganisms, providing a natural digestive enzyme supplement.

In addition, Anthony Collier, president and CEO of National Enzyme Company, explains that "Dr. Edward Howell believed that forcing the body to build all of its own enzymes rather than utilizing naturally occurring food enzymes robs the body of energy and resources it could put to use for other metabolic functions. He believed many chronic diseases were the result." Supplemental digestive enzymes support digestion and nutrient absorption. Incomplete digestion can cause digestive discomfort which may be reduced by enzyme supplements.

DO DIGESTIVE ENZYME SUPPLEMENTS REQUIRE A PROTECTIVE COATING OR CAPSULE?

The majority of supplemental enzymes on the retail shelves do not have protective coatings but this doesn't mean that they will be ineffective. This is because the requirement for a protective or enteric coating is based upon the pH stability of a given enzyme. Animal-based pancreatic enzymes have a narrow pH stability range that does not allow survival through the acidity of the stomach. Pancreatic enzymes must be enteric coated to deliver an efficacious level of activity.

In contrast, many plant and microbial enzymes have a broad pH stability range. These vegetarian enzymes do not require the protective coating. In fact, a protective coating may actually decrease the efficacy of these enzymes which function in "pre-digestion" in the upper stomach. Dr. Howell explained that natural food enzymes and supplemental enzymes begin digestion as soon as they are mixed with food. This pre-digestive process continues in the upper stomach for one-half to one hour or until the rising acidity inactivates the enzymes. Interestingly, in vitro studies indicate that many of these enzymes are not permanently denatured. These proteins are able to regain their functional conformation and contribute digestive activity in the small intestine.

WHAT ARE THE DIFFERENT TYPES OF DIGESTIVE ENZYMES?

Enzymes used in digestive supplements fall into three broad categories: proteases, lipases and carboxydrasases. Proteases break down proteins from meats, cheese, legumes, nuts and other dietary sources. Lipases digest dietary fats including butter and oils. Carboxydrasases break down starches, sugars and other carbohydrates common in breads, cereals, fruits and vegetables.

PROTEASES

Proteins are complex molecules made up of long chains of 22 different amino acids. The digestion of protein requires many different proteases with different bond specificities. Common digestive proteases found in dietary supplements include fungal protease, peptidase, neutral bacterial protease, bromelain, papain, trypsin and chymotrypsin. Figure Two illustrates a simplified peptide chain and the interaction of various supplemental enzymes to break down the molecule. Some proteases break internal bonds and are called endopeptidases. Trypsin, chymotrypsin, bromelain and papain are examples of endopeptidases. Other proteases cleave single amino peptidases from the ends of a peptide chain. These enzymes are called exopeptidases and include both the aminopeptidases and the carboxyptidases. Fungal proteases often include both endopeptidase and exopeptidase activity. The action of endopeptidases creates smaller peptides with more ends from which the exopeptidases can release additional free amino acids. Since each type of protease acts most effectively on the bonds associated with certain amino acids or groups of amino acids, combining different proteases from different source organisms or even different fermentation processes provides...
a broader range of digestive capability. These proteases work synergistically with endogenous enzymes to help digest the dietary proteins.

LIPASES

These enzymes catalyze the hydrolysis of triglycerides of simple fatty acid esters, yielding mono- and diglycerides, glycerol and free fatty acids. Lipases typically have broad substrate specificity on the fats and oils of vegetable and animal origins. Lipases from different source organisms have different specificities therefore combining different lipases from different source organisms may provide a broader range of digestive capability. Lipases work synergistically with endogenous enzymes to help digest fatty foods. Common digestive lipases are typically of either fungal or pancreatic origin.

CARBOHYDRASES

Carbohydrase is the generic term for any enzyme that breaks down carbohydrates. This group of enzymes includes the starch-breaking enzymes as well as sugar-breaking enzymes and fiber-breaking enzymes. These enzymes play an important role in energy metabolism as glucose is the primary energy source for the human body. The starch-breaking enzymes include amylase, glucoamylase and diastase. Sugar-breaking enzymes include lactase, invertase and alpha-galactosidase. Fiber-breaking enzymes include cellulase, hemicellulase, beta-glucanase, pectinase, phytase, and xylanase. Undigested carbohydrates may pass to the intestine and cause abdominal discomfort including bloating, gas and flatus when they are fermented by intestinal microorganisms.

Starch-Breaking Enzymes

Like protein digestion, starch digestion can be optimized by a combination of multiple enzymes, especially amylase and glucoamylase. Starch is made up of two different polysaccharides. Amylose consists of straight chains of glucose connected by alpha-1,4-glucosidic bonds. Amylopectin is a branched polysaccharide of alpha-1,4-glucosidic bonds with alpha-1,6-glucosidic bonds creating the branching points. Figure Two illustrates the digestion of starch by amylase and glucoamylase. Amylase randomly breaks the interior alpha-1,4 bonds (black bars) that combine glucose in straight chains in amylose and amylpectin. However, the alpha-1,6 bonds (blue bars) that create branches block amylase action and produce limit dextrins (blue circle). Glucoamylase cleaves terminal alpha-1,4 bonds as well as the alpha-1,6 bonds at these branching points. This allows amylase to again begin cleaving the alpha-1,4 bonds that were previously inaccessible.

Figure Two. Synergistic Protein Digestion

Figure Three. Synergistic Starch Digestion
Sugar-Breaking Enzymes

Lactase breaks down lactose, the sugar found in milk and dairy products. As human beings age, lactase secretion decreases and the consumption of dairy products become a discomfort for many. In addition, some ethnic groups are more likely to have low lactase levels. Worldwide estimates indicate that as much as 70% of the adult population suffers from lactase deficiency. Supplemental lactase works alongside any lactase the body produces to gain the benefits of dairy consumption without the gastric distress associated with lactose intolerance. Research indicates that many individuals who believe themselves to be lactose intolerant avoid consumption of dairy products which may result in a lower intake of calcium with possible associated nutritional and physiological consequences.

Alpha-galactosidase breaks down the indigestible sugars, often referred to as the raffinose-series sugars, found in legumes, cruciferous vegetables and other vegetables. When human beings consume these vegetables, the indigestible sugars pass into the intestines where they are fermented by bacteria causing gas, bloating, discomfort and pain, not to mention the opportunity for embarrassment. Supplemental alpha-galactosidase digests these sugars before they reach the intestine and eliminates their availability for fermentation and gas production.

Fiber-Breaking Enzymes

This group of enzymes is capable of hydrolyzing the non-digestible carbohydrates that comprise fiber prevalent in many fruits, vegetables, grains, and herbs. While fibers are an important part of a healthy diet they can also act as anti-nutritive factors. Fibers may bind to minerals and other nutrients, blocking their bioavailability and preventing their absorption. Fiber-breaking enzymes function to break up these fibers to improve nutrient bioavailability as well as decreasing the bulking effect of fibrous foods.

A full spectrum blend that includes all the types of enzymes listed above synergistically supports a more complete digestion of food. Naturally occurring compounds in foods are often combinations of the major nutrients such as glycoproteins, glycolipids and lipoproteins. Glycoproteins are proteins that contain oligosaccharides as part of their structure. These sugar units can inhibit digestion by the endogenous proteases of the human digestive tract. Carbohydrases must first breakdown the sugar component of the compound to allow proteases access to the peptide. Thus carbohydrases work synergically with proteases to breakdown the ingested glycoprotein. Likewise carbohydrases and lipids work together to break down glycolipids and lipases and proteases act synergically to digest dietary lipoproteins. Another example of digestive synergism occurs with the non-digestible cell walls of plant-based foods which may limit digestion. Fiber-breaking enzymes can help open the cell and allow the other enzymes access to the proteins, carbohydrates and fats within the cell. Like fiber, the proteins known as lectins can also limit digestion as they bind carbohydrates. Supplemental enzymes also work synergistically with the digestive enzymes produced by the human body.