Digestion & Enzymes

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What are enzymes?

Proteins comprise an essential part of our diet and can also be generated inside every one of our cells. One class of proteins called enzymes are critical in every major biochemical process to catalyze, or accelerate, chemical reactions.

There are six main types of enzymes each with different reaction capabilities: transferases, ligases, oxidoreductases, isomerases, lyases, and hydrolases. Digestive enzymes are classified as hydrolases and catalyze reactions by the addition of water to a macronutrient substrate to generate smaller bioactive molecules that are absorbed for cellular nutrition.

Enzymes contain "active sites" where specific target molecules, or substrates, bind and undergo chemical transformation. Macronutrient substrates include proteins, fats, and carbohydrates. Common digestive enzymes that bind with macronutrient substrates include proteases, peptidases, amylases, and lipases.

How does digestion work?

The human digestive system facilitates a dynamic and sophisticated response to food ingestion. The food response is led by the stomach, intestine, and pancreas, with some help from the central nervous system. The process begins with salivary glands in the mouth releasing amylase to initiate the digestion of carbohydrates. In the stomach, food digestion ramps up through acid-mediated hydrolysis and peristaltic contractions. The stomach accelerates protein digestion by the release of an endopeptidase enzyme called pepsin.

Partially digested food, now called chyme, passes in to a long, tube-like organ called the small intestine. The inner part of this tube is called the lumen, whereas the wall of the tube contains distinct cells that specialize in mucin secretion, immune surveillance, or further digestion and absorption. A single cell layer called the epithelium separates the lumen from the intestinal wall.

The small intestine is composed of three parts: the duodenum, jejunum, and ileum, in that order. The uppermost and shortest component of the small intestine, the duodenum, specializes in digestion. It is here that bicarbonate is released to neutralize the acidic pH of chyme for optimal activity of digestive enzymes such as endopeptidases, exopeptidases, amylase and lipase that are secreted by the pancreas. Additionally, bile salts from the liver help emulsify dietary fats to enable effective pancreatic lipase activity.

The duodenum's "brush border," or interface of the lumen and the epithelium, comprises additional enzymes that further break down macronutrients. Altogether, more than 20 digestive enzymes are produced across the salivary glands, stomach, pancreas, and small intestine.

The biochemical products of digestion include amino acids from proteins, fatty acids from fats, and monosaccharides from carbohydrates. These nutrients are readily absorbed by the epithelium along the remaining length of the small intestine that includes the jejunum and ileum. Undigested or unabsorbed components of the chyme, such as certain plant fibers or excess nutrients, pass to the large intestine where they can be fermented and metabolized by gut microbes.

The role of enzymes in the human digestive system.

Digestive juices and enzymes	Substrate digested	Product formed
Saliva Amylase	Starch	Maltose
Gastric Juice Protease (pepsin) and hydrochloric acid	Proteins	Partially digested proteins (peptides)
Pancreatic juice Proteases (trypsin) Lipases Amylases	Proteins Fats Starch	Peptides into amino acids Fatty acids and glycerol Maltose
Intestinal enzymes Peptidases Sucrase Lactase Maltase	Peptides Sucrose (sugar) Lactose (milk sugar) Maltose	Amino acids Glucose and fructose Glucose and galactose Glucose
Bile from the liver Bile salts	Fat globules	Micelles

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Why supplement with enzymes?

The human body has several ways to communicate an opportunity for better digestion. Common signs of insufficiently digested food and chyme include flatulence, bloating, occasional indigestion, and undigested food in the stool. Gas is the direct byproduct of bacterial fermentation of under-digested food or under-hydrolyzed chyme. Excess gas can lead to bloating and abdominal discomfort.

Common food intolerances include dairy lactose, wheat gluten, histamine, and FODMAPs (fermentable oligo-, di-, mono-saccharides and polyols) such as the complex galacto-oligosaccharide carbohydrates found in beans, dairy foods, and certain root vegetables. Several clinical studies have suggested that oral microbial enzyme supplementation can reduce symptoms associated with occasional indigestion or food intolerances. For example, beta-galactosidase (or "lactase") supplementation has been clinically shown to improve lactose digestion and improve gastrointestinal comfort following milk consumption. Similarly, alpha-galactosidase supplementation reduced severity of flatulence following consumption of cooked beans.

Enzyme supplementation is also an approach to support digestive health in older adults, especially those with food intolerances. Advancing age is associated with greater digestive discomfort and distress, as well as decreased digestive enzyme activity. For example, release of pepsin in to the stomach has been shown to decline with advancing age. Several observational clinical studies have also suggested that pancreatic enzymes critical for digestion show decreased output or activity with older age.

There is also evidence for decreased bicarbonate secretion with age, which leads to decreased duodenal pH and pancreatic enzyme activity. In contrast to human and porcine enzymes, it is important to note that many microbial, fungal, and plant enzymes can digest macronutrients in both acidic and neutral pH environments. Such microbial enzymes are acid-resistant and can promote digestion across both the stomach and duodenum.

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