**Enzymes**

Practically all of the numerous and complex biochemical reactions that take place in animals, plants, and microorganisms are regulated by enzymes.

The existence of enzymes was established in the middle of the 19th century by scientists studying the process off fermentation. The discovery of the role of enzymes a catalysts  followed rapidly. Developments before 1850 included (in 1833) the separation from malt of the enzyme amylase, which converts starch into sugar, and (in 1836) the isolation from the stomach wall of animals of a component of gastric juice that could partially digest food in a test tube, the enzyme pepsin.

Enzymes were known for many years as ferments, a term derived from the Latin word for yeast. In 1878 the name enzyme, from the Greek words meaning “in yeast,” was introduced; since the late 19th century it has been employed universally.

**Chemical Nature**

All enzymes were once thought to be proteins, but since the 1980s the catalytic ability of certain nucleic acids, called ribozymes (or catalytic RNAs), has been demonstrated, refuting this axiom. Because so little is yet known about the enzymatic functioning of RNA, this discussion will focus primarily on protein enzymes.

A large protein enzyme molecule is composed of one or more amino acid chains called polypeptide chains. The amino acid sequence determines the characteristic folding patterns of the protein’s structure, which is essential to enzyme specificity. If the enzyme is subjected to changes, such as fluctuations in temperature or pH, the protein structure may lose its integrity (denature) and its enzymatic ability. Denaturation is sometimes, but not always, reversible.

Each enzyme is able to promote only one type of chemical reaction. The [compounds](https://www.merriam-webster.com/dictionary/compounds) on which the enzyme acts are called [substrates](https://www.britannica.com/science/substrate-enzymatic-reactions). Enzymes operate in tightly organized metabolic systems called pathways. A seemingly simple biological phenomenon—the contraction of a [muscle](https://www.britannica.com/science/muscle), for example, or the transmission of a nerve impulse—actually involves a large number of chemical steps in which one or more [chemical compounds](https://www.britannica.com/science/chemical-compound)(substrates) are converted to substances called products; the product of one step in a metabolic pathway serves as the substrate for the succeeding step in the pathway.

**Cofactors**

Some enzymes cannot function unless they have a specific non-protein molecule attached to them. These are called cofactors. For instance, carbonic anhydrase, an enzyme that helps maintain the pH of the body, cannot function unless it is attached to a zinc ion.

Although some enzymes consist only of protein, many are complex proteins; i.e., they have a protein component and a so-called cofactor. A complete enzyme is called a holoenzyme; if the cofactor is removed, the protein, no longer enzymatically active, is called the apoenzyme. A cofactor may be an organic molecule, such as a vitamin—or an inorganic metal ion - a metal—such as iron, copper, or magnesium—a moderately sized organic molecule called a prosthetic group, or a special type of substrate molecule known as a coenzyme. The cofactor may aid in the catalytic function of an enzyme, as do metals and prosthetic groups, or take part in the enzymatic reaction, as do coenzymes.

**Difference between Apo enzyme and co-factor:**

* Apo enzyme is protein part of enzyme hence a macromolecule whereas co factor is the non protein part of enzyme hence a micro molecule.
* Apo enzyme is an enzyme which acts only in presence of a co-factor whereas co-factor may be metal ion or a complex organic compound makes an Apo enzyme functional.
* Apo enzyme is thermo-labile whereas co-factor is thermostable.
* Apo enzyme conducts enzymatic activities whereas co-factor moulds the enzyme or co enzyme or carries the groups removed from the substrate.
* Apo enzyme is specific for an enzyme system whereas co-factor work with many enzymes.

**Classification and nomenclature**

The first enzyme name, proposed in 1833, was diastase. Sixty-five years later, French microbiologist and chemist Émile Duclaux suggested that all enzymes be named by adding -ase to a root indicative of the nature of the substrate of the enzyme. Although enzymes are no longer named in such a simple manner, with the exception of a few—e.g., pepsin, trypsin, chymotrypsin, papain—most enzyme names do end in -ase.

Any systematic classification of enzymes should be based on a common property or quality that varies sufficiently to be useful as a distinguishing feature. In this regard, three properties of enzymes could serve as a basis for enzyme classification—the exact chemical nature of the enzyme, the chemical nature of the substrate, and the nature of the reaction catalyzed. In addition, although, as indicated above, early attempts at enzyme classification were based on the nature of broad groups of substrates (e.g., enzymes called carbohydrases act on carbohydrates), close functional similarities among enzymes in different groups were often obscured.

By general agreement, enzymes now are classified according to their substrates and the nature of the reaction they catalyze.

In an attempt to devise a rational system of enzyme nomenclature, two names are given to an enzyme. One, known as the systematic name, is based on logical principles but is often long and awkward; the other, “trivial” name is short and generally used but not usually exact or systematic. In the scheme of systematic nomenclature, six main groups of enzymatic reactions are recognized; each catalyzes one reaction type and is subdivided on the basis of detailed definitions of the reaction catalyzed and of the substrate involved in the reaction.

An enzyme will interact with only one type of substance or group of substances, called the substrate, to catalyze a certain kind of reaction. Because of this specificity, enzymes often have been named by adding the suffix “-ase” to the substrate’s name (as in urease, which catalyzes the breakdown of urea). Not all enzymes have been named in this manner, however, and to ease the confusion surrounding enzyme nomenclature, a classification system has been developed based on the type of reaction the enzyme catalyzes. There are six principal categories and their reactions:

### 1. Oxidoreductases

The enzyme oxidoreductase catalyzes the oxidation reaction where the electrons tend to travel from one form of a molecule to the other. Examples of oxidoreductase enzymes include, peroxidases, hydroxylases, oxygenases, and alcohol oxidoreductases.

*Highlighted for their potential is the production of renewable building blocks from plant biomass and their use for the manufacture of sustainable chemicals and materials in lignocellulose biorefineries, they tend to have*[*complex storage requirements*](https://pubmed.ncbi.nlm.nih.gov/12217049/)*.*

### 2. Transferases

The transferases enzymes help in the transportation of the functional group among acceptors and donor molecules. Examples of transferases include riboflavin synthase and chlorophyll synthase.

The storage temperature of -70 degrees C in a[laboratory-grade ultra-low freezer unit](https://k2sci.com/products/ultra-low-freezers-86/)was found in[clinical studies](https://pubmed.ncbi.nlm.nih.gov/8087206/)to guarantees the best stability.

### 3. Hydrolases

Hydrolases are hydrolytic enzymes that catalyze the hydrolysis reaction of a substrate by adding water to cleave the bond and hydrolyze it. Examples of hydrolase enzymes include Esterases including lipases, phosphatases, glycosidases, peptidases, and nucleosidases.

Hydrolases are best stored at –20 °C.

### 4. Lyases

Lyase is an enzyme that breaks apart various chemical bonds by means of an "elimination" reaction. Lyases are different from other enzymes for only one substrate is required for the reaction in one direction, but two substrates are essential for the reverse reaction. Examples of Lyase include decarboxylase, dehydratase, and aldolase.

*The cold storage recommendations vary on [Lysase enzyme samples](https://pubmed.ncbi.nlm.nih.gov/12217049/) depending upon short- and long-term storage needs. For ultimate long-term preservation,*[*ultra-low freezer housing at -80°C*](https://k2sci.com/news/a-guide-to-the-different-lab-refrigerators-and-freezers/)*is optimal. Most experts advise pairing the lysase samples with certain reagents to assist with stabilization.*

### 5. Ligases

A Ligases is an enzyme that catalyzes the bonding of two large molecules. Examples of ligases are Threonyl-tRNA synthetase, Acetyl-CoA carboxylase, and Succinyl-CoA synthetase.

Ligation reactions are optimal at 12 to 16 °C. Performing ligation reactions at this temperature helps to maintain stability.[High-performance refrigerators](https://k2sci.com/products/laboratory/)options for enzyme housing of this type are available at K2 Scientific.

### 6. Isomerases

An Isomerases is a type of enzymes that changes a molecule from one isomer to another. Examples of isomerases include triose phosphate isomerase, bisphosphoglycerate mutase, and photoisomerase. Isomerases can help prepare a molecule for subsequent reactions such as oxidation-reduction reactions.

Dilution of this type of enzyme in a buffered solution and stored at –20 °C. At this temperature, the enzyme is shown in clinical studies to retains activity for at least two years.

Oxidoreductases and transferases account for about 50 percent of the approximately 1,000 enzymes recognized thus far.

**Factors Affecting Enzyme Activity**

Because enzymes are not consumed in the reactions they catalyze and can be used over and over again, only a very small quantity of an enzyme is needed to catalyze a reaction. A typical enzyme [molecule](https://www.britannica.com/science/molecule) can convert 1,000 substrate molecules per second. The rate of an enzymatic reaction increases with increased substrate concentration, reaching maximum velocity when all active sites of the enzyme molecules are engaged. The enzyme is then said to be saturated, the rate of the reaction being determined by the speed at which the active sites can convert substrate to product.

**Inhibition**

To ensure that the body's systems work correctly, sometimes enzymes need to be slowed down. For instance, if an enzyme is making too much of a product, there needs to be a way to reduce or stop production.

Enzymes' activity can be inhibited in a number of ways:

***Competitive inhibitors*** - a molecule blocks the active site so that the substrate has to compete with the inhibitor to attach to the enzyme.

***Non-competitive inhibitors*** - a molecule binds to an enzyme somewhere other than the active site and reduces how effectively it works.

***Uncompetitive inhibitors*** - the inhibitor binds to the enzyme and substrate after they have bound to each other. The products leave the active site less easily, and the reaction is slowed down.

***Irreversible inhibitors*** - an irreversible inhibitor binds to an enzyme and permanently inactivates it.

**Mechanism Of Enzyme Action**

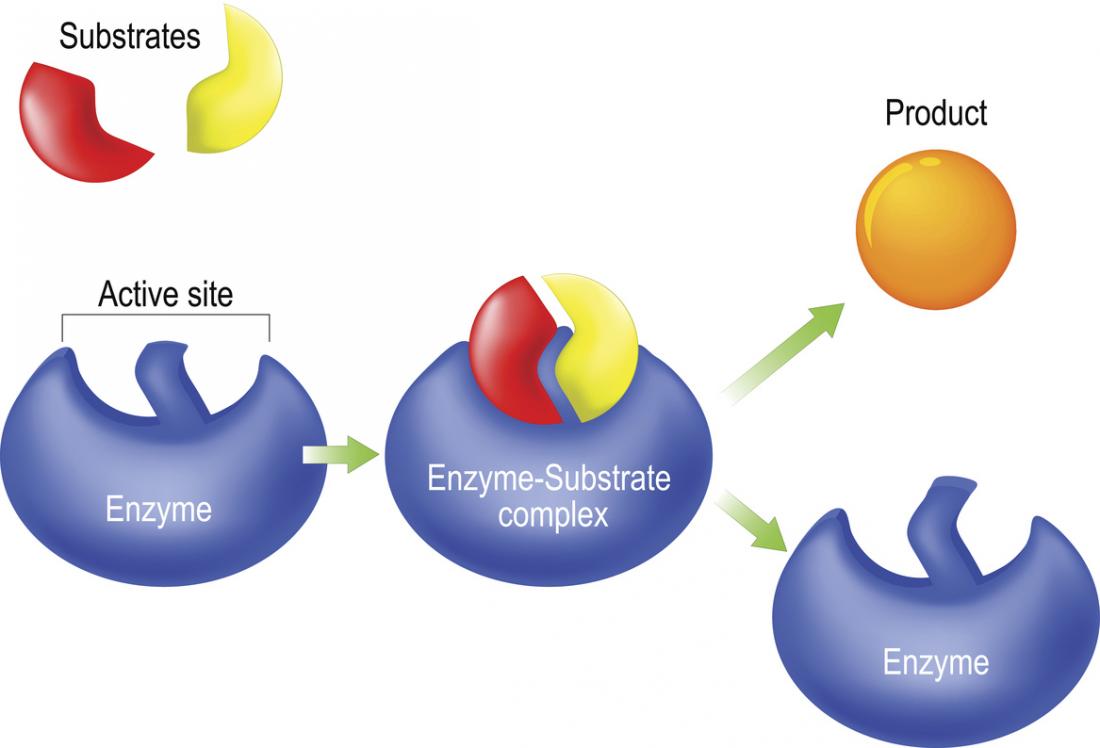
In most chemical reactions, an energy barrier exists that must be overcome for the reaction to occur. This barrier prevents complex molecules such as proteins and nucleic acids from spontaneously degrading, and so is necessary for the preservation of life. When metabolic changes are required in a cell, however, certain of these complex molecules must be broken down, and this energy barrier must be surmounted. Heat could provide the additional needed energy (called activation energy), but the rise in temperature would kill the cell. The alternative is to lower the activation energy level through the use of a catalyst. This is the role that enzymes play. They react with the substrate to form an intermediate complex—a “transition state”—that requires less energy for the reaction to proceed. The unstable intermediate compound quickly breaks down to form reaction products, and the unchanged enzyme is free to react with other substrate molecules.

Only a certain region of the enzyme, called the active site, binds to the substrate. The active site is a groove or pocket formed by the folding pattern of the protein. This three-dimensional structure, together with the chemical and electrical properties of the amino acids and cofactors within the active site, permits only a particular substrate to bind to the site, thus determining the enzyme’s specificity.

Enzyme synthesis and activity also are influenced by genetic control and distribution in a cell. Some enzymes are not produced by certain cells, and others are formed only when required. Enzymes are not always found uniformly within a cell; often they are compartmentalized in the [nucleus](https://www.britannica.com/science/nucleus-biology), on the [cell membrane](https://www.britannica.com/science/cell-membrane), or in subcellular structures. The rates of enzyme synthesis and activity are further influenced by [hormones](https://www.britannica.com/science/hormone), neurosecretions, and other chemicals that affect the cell’s internal [environment](https://www.merriam-webster.com/dictionary/environment).

How enzymes work

A [substrate](http://www.rsc.org/Education/Teachers/Resources/cfb/enzymes.htm) binds to the [active site](https://www.ncbi.nlm.nih.gov/books/NBK21166/) of an enzyme and is converted into products. Once the products leave the active site, the enzyme is ready to attach to a new substrate and repeat the process.



Enzyme lock and key model

The "lock and key" model was first proposed in 1894. In this model, an enzyme's active site is a specific shape, and only the substrate will fit into it, like a lock and key.

This model has now been updated and is called the induced-fit model.

In this model, the active site changes shape as it interacts with the substrate. Once the substrate is fully locked in and in the exact position, the catalysis can begin.

**The perfect conditions**

Enzymes can only work in certain conditions. Most enzymes in the human body work best at around 37°C - body temperature. At lower temperatures, they will still work but much more slowly.

Similarly, enzymes can only function in a certain pH range (acidic/alkaline). Their preference depends on where they are found in the body. For instance, enzymes in the intestines work best at 7.5 pH, whereas enzymes in the stomach work best at pH 2 because the stomach is much more acidic.

If the temperature is too high or if the environment is too acidic or alkaline, the enzyme changes shape; this alters the shape of the active site so that substrates cannot bind to it - the enzyme has become denatured.

## Properties Of Enzymes

Enzymes are biocatalysts of protein in nature, which accelerate the rate of biochemical reactions but do not affect the nature of final product. Like catalyst the enzymes regulate the speed and specificity of reaction without being used up but unlike catalysts enzymes are produced by the living cells only. Like catalysts enzymes also influence the rate of biochemical reaction so that they can take place at a relatively low temperature. Thus the enzymes are known to lower the activation energy. In many cases enzymes initiate the biological reaction.

The term enzymes are derived from Greek word enzymes which means ‘in yeast’ because the yeast cells were first to reveal the enzyme activity in living organisms. The term enzyme was coined by W. Kuhne in the year 1878.

## 

## *Properties Of Enzymes Can Be Classified Into:*

1. Physical properties
2. Chemical Properties
3. General properties

**Physical Properties of Enzymes**

* Physically enzymes behave as colloids or as substance of high molecular weight.
* Enzymes are destroyed or inactivated at temperature below the boiling point of water.
* At 60 degrees Celsius most enzymes in liquid medium are inactivated.
* Dried enzymes extract can endure temperature 100 degree Celsius to 120 degrees Celsius or even higher. Thus enzymes are thermos-labile.
* There is always a specific temperature of optimum activity of every enzyme, which usually ranges from 25 degrees Celsius to 45 degrees Celsius. Enzymatic action is highest at 37 degrees Celsius and enzymes become inactive when temperature rises above 60 degrees Celsius.

#### Chemical Properties Of Enzymes

* Catalytic properties: Enzymes are biological catalyst. The small quantity of enzymes catalyses the larger quantities of substances. It means, enzymes have high capability to convert giant quantities of substrate into product. Enzymes increase the rate of reaction and remain unaffected by the reaction which they catalyse.
* Specificity of enzyme: Enzymes are highly specific in nature, i.e., a particular enzyme can catalyse a particular reaction. For example, Enzyme sucrase can catalyse only hydrolysis of sucrose.

#### General Properties Of Enzymes

* Enzymes initiate and accelerate the rate of biochemical reaction.
* The activity of enzymes depends upon the acidity of medium (pH specific). Each catalyst is most active at a specific pH. For example, pH 2 for pepsin, pH 8.5 for trypsin. Most intracellular enzymes function at near neutral pH.
* Enzymes can accelerate the reaction in either direction.
* All enzymes possess active sites which participate in the biochemical reactions.
* Enzymes are very unstable compounds mostly soluble in water, dilute glycerol, NaCl and dilute alcohol.
* Enzymes act actively at optimum temperature.
* All enzymes are protein in nature but all proteins may not be an enzyme.
* Enzymes lower the energy of activation of the substance molecule so the biochemical reaction can take place at normal body temperature which is 37 degrees Celsius.

## 

## *The Most Important Properties Of An Enzyme:*

1. Catalytic Property
2. Specificity
3. Reversibility
4. Sensitiveness to heat and temperature and pH

#### Catalytic Property:

Enzymes have extra-ordinary catalytic power. They are active in very small quantities. A small amount of enzyme is enough to convert a large quantity of substrate. The enzymes remain unchanged after the reaction. The turnover number of enzymes ranges from 0.5 to 600000. Turn over number is the number of substrate molecules converted by one molecule of enzymes per second when its active site is saturated with substrate.

#### Specificity:

Enzymes are very specific in their action. Particular enzymes act on particular substrates only. Enzymes are also specific to a particular type of reaction. In some rare cases, the specificity may not be too strong. Enzymes show different types of specificity as follows:

1. Bond Specificity: It is also called as relative specificity. Here the enzymes are specific for a bond. eg; peptidase is specific or peptide bond, lipase is specific for ester bond in a lipid.
2. Group Specificity: It is also called structural specificity. Here the enzymes are specific for a group. eg; pepsin hydrolyse the peptide bonds in with the amino group belongs to aromatic amino acids.
3. Substrate Specificity: It is also called absolute specificity. Here the enzyme acts only on a particular substrate. eg; arginase acts only on arginine; carbonic anhydrase acts only on carbonic acid.
4. Optical Specificity: It is also called stereo-specificity. This is the highest specificity shown by an enzyme. Here the enzymes are specific not only to the substrate but also to its optical configuration. e.g. L amino acid oxidase acts only L-amino acids, not on D-amino acids. Similarly, the alpha-amylase act only on alpha-14 glycosidic linkage of starch and glycogen. It is not able to hydrolyse the beta-14 glycosidic linkage of cellulose.
5. Co-factor Specificity: This shows that enzymes are not only specific to the substrate but also specific to its co-factors.
6. Geometric Specificity: Here the specificity is very less. Some enzymes will work with a small range of similar substrates having similar structural geometry. e.g. alcohol dehydrogenase can oxidise methanol and n-propanol to aldehydes.

#### Reversibility:

Most of the enzymes catalysed reactions are reversible. The reversibility of the reaction depends upon the requirements of the cell. In some cases, there are separate enzymes for forward and reverse reaction. Some enzyme-catalysed reactions are not reversible.

#### Sensitivity To Heat, Temperature And pH:

Enzymes are very sensitive to heat and temperature. They are thermolabile. The maximum activity of Associate in Nursing protein is at traditional temperature. The correct temperature for the utmost activity is termed optimum temperature. Enzymes will be inactive at very low temperatures; this is the reason for preserving food and vegetables in the refrigerator. The enzymatic activity increases with the increase in temperature up to a certain level. At higher temperature (60-70 degree Celsius), the enzyme is destroyed or denatured. An enzymes active at very high temperature is Taq-Polymerase used in PCR reactions. The optimum temperature for it is 75 to 80 degrees Celsius.

The optimum pH of most endo-enzyme is pH 7.0 (neutral pH). However, digestive enzymes can function at different pH. For example, salivary amylase act best at pH 6.8, pepsin act best at pH2 etc. Any fluctuation in pH scale from the optimum causes ionization of R-groups of amino acids that decrease the protein activity. Sometime a change in pH causes the reverse reaction, e.g. at pH 7.0 phosphorylase break down starch into glucose 1- phosphate while at pH5 the reverse reaction occurs.

**Isolation and Purification of Enzymes**

Enzymes are mainly a type of protein and a protein needs to be isolated in a pure state for analysis. Isolation and purification of enzymes can be done using some simple steps and these steps include precipitation, concentration, extraction, purification and storage.

Isolation of enzymes has been known as a process of differentiating enzymes from crude extracts or cells. Isolation and purification of enzymes can be helpful in differentiating enzymes and calculating their activity and recovery percentage. Isolation of enzymes can be done in some simple steps which can be cell disruption, supernatant removal or centrifugation. Cell disruption can be done using osmolysis, freeze-thaw cycles, ultrasonication, detergent lysis, enzymatic lysis or homogenisation. Supernatant removal can be done using a decantation process which has been a widely known process of obtaining supernatant. Centrifugation has been known as a process that needs to be conducted at a specific speed based on tissue, cells or other materials from where enzymes need to be isolated.

Isolation of enzymes can be done using ultrasound homogenisation, cryogenic grinding and lysis buffer. Ultrasound homogenisation can be used for isolating enzymes from soft tissues and this process has also been known to cause heat of the sample. Cryogenic grinding includes grinding of samples in liquid nitrogen. This process, which includes liquid nitrogen, has been seen to have a very lower temperature which protects enzymes during grinding. This process has mainly been seen to be used for isolating enzymes from hard tissues however; this process has also been seen to be time-consuming. Lysis buffer can be used for isolating enzymes from only animal cells or bacteria. Risk of degradation has been seen to be present in this process.

Purification processes of enzymes include size exclusion chromatography, ion-exchange chromatography, hydrophobic interaction chromatography, free-flow-electrophoresis, affinity chromatography and High-performance liquid chromatography (HPLC). Purification of an enzyme completes when Ultrafiltration and Lyophilization have been used and concentration of purified enzyme has been gained. Isolation and Purification of enzymes can also provide proper evaluation of purification yield.

Purification of enzymes has also been known as separation of enzymes from other substances. Purification of enzymes can be done in three types and those are purification by charge, purification by size and purification by specific binding sites. Purification by charge includes isoelectric focusing and exchange chromatography whereas purification by size includes size exclusion chromatography, preparative native gel electrophoresis and ultrafiltration. Purification by binding sites includes immunochromatography using antibodies, magnetic separation using magnetic antibodies and metal affinity chromatography using different binding sites.

**Role of enzymes**

Enzymes help speed up chemical reactions in the human body. They bind to molecules and alter them in specific ways. They are essential for respiration, digesting food, muscle and nerve function, among thousands of other roles.

*The digestive system* - enzymes help the body break down larger complex molecules into smaller molecules, such as glucose, so that the body can use them as fuel.

*DNA replication* - each cell in your body contains DNA. Each time a cell divides, that DNA needs to be copied. Enzymes help in this process by unwinding the DNA coils and copying the information.

*Liver enzymes* - the liver breaks down toxins in the body. To do this, it uses a range of enzymes.

***Role of enzymes in***[***metabolism***](https://www.britannica.com/science/metabolism)

Some enzymes help to break down large [nutrient](https://www.britannica.com/science/nutrient) molecules, such as proteins, [fats](https://www.britannica.com/topic/fat), and [carbohydrates](https://www.britannica.com/science/carbohydrate), into smaller molecules. This process occurs during the [digestion](https://www.britannica.com/science/digestion-biology) of foodstuffs in the stomach and intestines of animals. Other enzymes guide the smaller, broken-down molecules through the intestinal wall into the bloodstream. Still other enzymes promote the formation of large, complex molecules from the small, simple ones to produce cellular [constituents](https://www.merriam-webster.com/dictionary/constituents). Enzymes are also responsible for numerous other functions, which include the storage and release of energy, the course of reproduction, the processes of respiration, and vision. They are indispensable to life.

**Other functions**

Enzymes play an increasingly important role in [medicine](https://www.britannica.com/science/medicine). The [enzyme](https://www.britannica.com/science/enzyme) thrombin is used to promote the healing of [wounds](https://www.britannica.com/science/wound). Other enzymes are used to diagnose certain kinds of disease, to cause the remission of some forms of [leukemia](https://www.britannica.com/science/leukemia)—a disease of the blood-forming organs—and to counteract unfavourable reactions in people who are allergic to [penicillin](https://www.britannica.com/science/penicillin). The enzyme [lysozyme](https://www.britannica.com/science/lysozyme), which destroys [cell](https://www.britannica.com/science/cell-biology) walls, is used to kill [bacteria](https://www.britannica.com/science/bacteria). Enzymes have also been investigated for their potential to prevent [tooth decay](https://www.britannica.com/science/caries) and to serve as [anticoagulants](https://www.britannica.com/science/anticoagulant) in the treatment of [thrombosis](https://www.britannica.com/science/thrombosis), a disease characterized by the formation of a clot, or plug, in a [blood vessel](https://www.britannica.com/science/blood-vessel). Enzymes may eventually be used to control enzyme deficiencies and abnormalities resulting from diseases.

It might also be noted in passing that enzymes are used in industrial processes involving the preparation of certain chemical [compounds](https://www.merriam-webster.com/dictionary/compounds) and the tanning of leather. They also are valuable in [analytical](https://www.merriam-webster.com/dictionary/analytical) procedures involving the detection of very small quantities of specific substances. Enzymes are necessary in various food-related industries, including [cheese](https://www.britannica.com/topic/cheese) making, the brewing of [beer](https://www.britannica.com/topic/beer), the aging of [wine](https://www.britannica.com/topic/wine), and the baking of [bread](https://www.britannica.com/topic/bread). Enzymes also may be used to clean clothes. For some industrial uses of enzymes, see [baking](https://www.britannica.com/topic/baking).

**Health conditions related to enzyme imbalances.**

Metabolic disorders are often the result of not having enough of a certain enzyme. Parents can pass them to their children through genes (inherited). Some examples of inherited metabolic disorders include:

* [**Fabry disease**](https://my.clevelandclinic.org/health/diseases/16235-fabry-disease) prevents body from making enzymes (alpha-galactosidase A) that break down fat (lipids).
* [**Krabbe disease**](https://my.clevelandclinic.org/health/articles/6039-krabbe-disease-globoid-cell-leukodystrophy) (globoid cell leukodystrophy) affects enzymes needed for the protective covering (myelin) on nerve cells (Central Nervous System).
* [**Maple syrup urine disease**](https://my.clevelandclinic.org/health/diseases/21168-maple-syrup-urine-disease) affects enzymes needed to break down certain branch chain amino acids.

Other health conditions related to enzyme imbalances include:

* [**Crohn’s disease**](https://my.clevelandclinic.org/health/diseases/9357-crohns-disease) an imbalance of the bacteria in your gut (gut microbiome) may influence an autoimmune response of the intestinal tract. This may play a role in presentation and severity of Crohn’s disease.
* [**Exocrine pancreatic insufficiency (EPI**](https://my.clevelandclinic.org/health/diseases/21577-exocrine-pancreatic-insufficiency-epi)**)** is a condition where your pancreas doesn’t have enough digestive enzymes. You can’t break down food or absorb nutrients. Chronic [pancreatitis](https://my.clevelandclinic.org/health/diseases/8103-pancreatitis), [pancreatic cancer](https://my.clevelandclinic.org/health/diseases/15806-pancreatic-cancer), [diabetes](https://my.clevelandclinic.org/health/diseases/7104-diabetes-mellitus-an-overview) or [cystic fibrosis](https://my.clevelandclinic.org/health/diseases/9358-cystic-fibrosis)can lead to EPI.
* [**Lactose intolerance**](https://my.clevelandclinic.org/health/diseases/7317-lactose-intolerance) is a shortage of the enzyme needed to digest sugars in milk (lactose) and dairy.

## Application Of Enzymes In Medicine

#### Enzymes Used To Treat Disorders:

**These are used in three cases:**

1. To break the internal blood clots.
2. To dissolve the hardening of walls of blood vessels.
3. To dissolve the wound swelling to promote healing.

In some disorders like low blood pressure, or head or spinal injuries, there are chances of formation of blood clots. These clots lead to obstruction of blood flow to the target organ. This can be life-threatening if it is in the brain or heart which require a constant supply of oxygen and energy. The only way out then is to dissolve the clots.

These clots are usually removed by dissolution by enzymes that can break them.

Similarly, when there is atherosclerosis, hardening and thickening of blood vessel walls. This can lead to heart problems if untreated. The best way out at this junction is to decrease the fat intake and also dissolve the formed thickenings. Enzymes like serratiopeptidase and other work well.

For wound healing, the swelling formed might be painful and tend to form pus. Enzymes such as trypsin, chymotrypsin, serratiopeptidase are used to dissolve the swelling.

#### Enzymes Used To Assist Metabolism

In previous or geriatric patients, the digestive capacity is low due to insufficient secretion of digestive enzymes. Hence their gastrointestinal system cannot digest food materials with efficiency. In such cases, they can experience malnutrition, constipation, bloating, etc. To aid digestion, enzymes like Papain are administered orally after food for easier digestion.

#### Enzymes Used To Assist Drug Delivery

Some medicines have to be compelled to penetrate deeper tissues for higher action. For this, some enzymes are used along with drugs in intra-muscular injection forms to help proper penetration of tissues. One of such enzymes is Hyaluronidase.

This is a natural human protein gift in human spermatozoan to assist spermatozoan penetrate female internal reproductive organ tissue and fertilize with ova. Here the same enzyme is manufactured by rDNA technology and administered along with drugs to enable efficient drug delivery to the target site.

#### Enzymes To Diagnose Disorders

Enzymes of the liver, kidney, skeletal muscle, heart, etc. leak into blood during related disorders. Measuring the amount of the corresponding protein for his or her presence in high or low levels in blood indicates the particular disorder. This is why it is important to have enzymes in medicine.

Ex: Creatine kinase for muscle weakness and injury.

Similarly, by use of polymerase chain reaction (PCR), they help to diagnose genetic diseases in the prenatal stage for disorders like sickle cell anaemia, Huntington’s disease, beta-thalassemia, etc.

#### Enzymes Used In The Manufacture Of Medicines

Immobilised enzymes are used in the manufacture of many drugs and antibiotics. This is attainable as enzymes convert the pro-drug molecules to medication or beginning material to medication. Also, steroidal drugs are manufactured by enzyme action on plant steroids.

#### Enzymes Used In Toothpaste

Enzymes of papaya and pineapple are used in the dentifrice. They are found to remove the stain on teeth to give white and sparkling teeth.

## Types of Enzymes  Tens of thousands of different kinds of enzymes are believed to exist in the human body, each with a specific purpose. There are three general categories of enzymes: digestive enzymes, metabolic enzymes, and food or plant enzymes. The digestive enzymes category consists of the enzymes produced within your own body to help break down food into its basic components for digestion. Metabolic enzymes are found throughout our entire body – in our organs, bones, blood, and even within the cells that produce them. They function in support of our heart, lungs, kidneys and brain. Food and plant enzymes are naturally present in raw food. They generally serve the same function as digestive enzymes, but these are the enzymes that we may take in through our diets, as opposed to the ones our bodies produce. We can obtain these enzymes through eating fresh, raw and uncooked foods like fruits, vegetables, eggs, unpasteurized dairy, meat and fish. The modern diet generally revolves around processed and cooked food, but these processes destroy the naturally occurring enzymes contained in the food. This places a heavy burden on our bodies to subsidize the enzyme requirement for breaking down that food.  Raw food contains the necessary proportion and types of enzymes required to digest itself. This remains one of the biggest benefits of a diet centered around raw food. The major components of the food (sugar, protein, starch, fat) and their respective caloric amounts determine what type and quantity of enzymes are also present. For example, the enzyme amylase is found in high carbohydrate fruits like apples and peaches. Fruits that are high in fat, such as avocados, contain the enzyme lipase.  Below, we will focus on enzymes we obtain from food sources (animal, plant and fungal) and their respective usefulness.

### Animal-Based Enzymes

There is a homeopathic theory called the “Law of Similars” which some believe may apply to animal sourced enzymes. Although the source of animal-based enzymes we consume don’t originate from a human body, it is thought they may be similar enough that the human body might do a better job recognizing and utilizing them. However, it is important to note that this is merely a theory. 

Reliance on obtaining digestive enzymes from animal sources is challenging, because a majority of the meat and other animal byproducts we consume are processed, pasteurized and/or cooked, which destroys the natural enzymes. For vegetarians or vegans, animal enzymes are hardly an option, and consuming raw meat or eggs is a dangerous endeavor, due to the risk of bacterial contamination.  
From a digestive perspective, there are several important disadvantages associated with animal-based enzyme sources. Temperature sensitivity is one of these. The human body does not generally have the same temperature as the animal host of these enzymes, which can be destructive to the enzyme upon entering the gastrointestinal tract.   
Animal-based enzymes also function exclusively within a limited pH level range, which renders them fairly ineffective in the gut. They become unstable in a low pH level (acidic) environment, resulting in the enzyme being destroyed before it can perform its function. This pretty much eliminates the stomach as an operational environment. As a result, to take in animal enzymes, they are better delivered into the body within a protective enteric (polymer) coating capable of withstanding the stomach’s acidity. This means that the enzymes don’t become available to the body until they reach the small intestines. The most common type of animal enzymes used for dietary supplementation are pancreatic enzymes. However, for the reasons outlined above, the general consensus is the best sources of enzymes are plant and fungal.

### ****Plant-Based Enzymes****

Fruits and vegetables are commonly consumed in their raw, natural form. This alleviates the overarching issue with animal-based enzymes by preserving the integrity of the enzymes themselves. Additionally, plant-based digestive enzymes are effective over a broad scope of pH levels. This range is generally believed to be between 3.0 and 9.0, which is highly compatible with the human gastrointestinal environment. As a result, plant-based enzymes are well-suited for supporting comprehensive digestive health.  
Four important enzymes often found in plants are protease, amylase, lipase and cellulose. Protease breaks down protein that can be present in meat, fish, poultry, eggs, cheese and nuts. Amylase assists your body with the breakdown and subsequent absorption of carbohydrates and starches. Lipase aids the digestion of fat. When your diet includes lipase-rich foods, it eases the production burden on the gall bladder, liver and pancreas. Cellulase is present in many fruits and vegetables, and it breaks down food fibers, which increases their nutritional value to our bodies. The presence of cellulase in plant-based sources is important, because it is not naturally present in the human body.   
Fruits and vegetables are an ideal source for enzymes. They are enzyme-rich and easily consumed without needing to be cooked or processed, ultimately preserving the full functionality of the enzymes.

### ****Fungal Enzymes****

Fungal Enzymes have numerous uses. They are critical in the production and preparation of many food products, like beer, soy sauce, miso, baked goods, dairy and processed fruit. One of the oldest known applications is the role of yeast in alcohol fermentation. Fungal enzymes are commonly produced from a fungal source called Aspergillus. For example, Aspergillus oryzae is used in the preparation of sake and soy sauce, while Aspergillus sojae is also used in soy sauce preparation, as well as in miso soup.

One of the most popular and well known culinary fungi is the mushroom. Some mushroom species produce enzymes, including hydrolases, esterases, and phenol oxidases. Fungi and their enzymes can also be found in yeast spreads and certain types of cheeses, such as Camembert and blue cheeses.

Fungi can contain a variety of enzymes, such as protease, amylase, lipase, cellulase and tilactase (supports lactose absorption). Like plant enzymes, fungal enzymes are acid stable and can survive within the pH range of the stomach. They are also suitable for a vegetarian diet, unlike animal-sourced enzymes.

In summary, if you’re interested in increasing your enzyme intake efficiently, the usefulness of plant-sourced and fungal-sourced enzymes outweighs that of animal-sourced enzymes.

## Types of Digestive Enzymes

Each of the many different digestive enzymes targets a specific nutrient and splits it up into a form that can eventually be absorbed.

The most important digestive enzymes are:

* Amylase
* Maltase
* Lactase
* Lipase
* Proteases
* Sucrase
* Cellulases
* Acetylcholinesterase - breaks down the neurotransmitter acetylcholine in nerves and muscles.
* Helicase - unravels DNA
* DNA polymerase - synthesize DNA from deoxyribonucleotides.

1. Amylases

Amylases (α-, β-, γ-amylase) referred to enzymes related to enzymes, cleaving this glycoside. it is the name of a group of glycoside-degrading enzymes. α-amylase is endoamylase, it breaks starch into dextrin and α-maltose or 1,6-isomaltose. α-amylase and α-maltose are found in spleen, pancreas, malt and microorganisms. Alpha amylase from porcine pancreas has a molecular weight of 50000.

β-amylase is exoamylase, it is able to break down terminal fragments of starch chain and cleaves 2 molecules of glucose and produce  β-maltose. Amilopectin is cleaved only in 1-6 linkage and as a result “boundary dextrins” are formed. β-amylase is widely distributed in plant world.

γ-amylase (glucoamylase) is found in liver, intestine and microorganisms. It cleaves both 1-4 and 1-6 bonds like exoamylases, for example cleaves the glucose residues from glycogen. γ-amylase mainly is present in mushrooms.

Pig pancreatic and Aspergillus oryzae α-amylase is mainly used as an adjuvant therapy. Plant amylases have a certain advantage,  they are not destroyed by the highly acidic environment of the stomach..

Amylase is important for digesting carbohydrates. It breaks down starches into sugars.

Amylase is secreted by both the salivary glands and the pancreas. The measurement of amylase levels in the blood is sometimes used as an aid in diagnosing various pancreas or other digestive tract diseases.

High levels of amylase in the blood may mean you have:

* A blocked or injured duct of the pancreas
* [Pancreatic cancer](https://www.verywellhealth.com/pancreatic-cancer-symptoms-514278)
* Acute [pancreatitis](https://www.verywellhealth.com/acute-or-chronic-pancreatitis-symptoms-and-treatments-3520426), which is a sudden inflammation of the pancreas2

Low levels of amylase may mean you have chronic pancreatitis (ongoing inflammation of the pancreas) or liver disease.

### 2. Maltase

The small intestine releases maltase, which is responsible for breaking down maltose (malt sugar) into [glucose](https://www.verywellhealth.com/glucose-5188205) (simple sugar). The body uses glucose for energy.

During digestion, starch is partially transformed into maltose by amylases. The maltase enzyme then changes maltose into glucose. This sugar is then either used immediately by the body or stored in the liver as glycogen for future use.

### 3.Lactase

[Lactase](https://www.verywellhealth.com/the-benefits-of-lactase-supplements-89470) (also called lactase-phlorizin hydrolase)is an enzyme that breaks down lactose, a sugar found in dairy products. It turns lactose into the simple sugars glucose and galactose.

Lactase is produced by cells known as enterocytes that line the intestinal tract. Lactose that is not absorbed is fermented by bacteria in the gut. This can cause you to have [gas](https://www.verywellhealth.com/symptoms-and-treatment-of-intestinal-gas-1942725) and an upset stomach.

4. Cellulases

Celullase catalyzes the bond cleavage of cellulose. It cleaves the cellulose to produce cellobiose. Cellulases are mainly found in bacteria and fungi (Aspergillus oryzae).

Higher animals don’t produce cellulase. Cellulase plays an important role in the digestion of food in the first section of the stomach of ruminant animals. Cellulase is usually used in the combination with other digestive enzymes.

5. Lipases

 Lipases are a subclass of the esterases. Triglycerides and phospholipids are completely or partially cleaved by lipase and free higher fatty acids are produced. In addition to this, glycerol, mono- or diglycerides or phosphatide acids are produced. Pancreatic lipase cleaves only α və α1-fatty acids, lipase of intestinal wall – also β-glucose. Fats are absorbed as β-monoglycerides and converted into neutral fats in intestinal mucosa. Lipase is produced by the pancreas or fungi Rhizopus arrhizus. They are used as an adjuvant therapy in the combination with proteases or amylases.

Lipase is responsible for the breakdown of fats into fatty acids and glycerol (simple sugar alcohol). It's produced in small amounts by your mouth and stomach, and in larger amounts by your pancreas.

### 6.Proteases

Also called peptidases, proteolytic enzymes, or proteinases, these digestive enzymes break down proteins into amino acids. They also play a role in numerous body processes, including:

* Cell division
* Blood clotting
* Immune function4

Proteases are produced in the stomach and pancreas. The main ones are:

* **Pepsin**:Pepsin is secreted by the stomach to break down proteins into [peptides](https://www.verywellhealth.com/what-is-a-peptide-5084580), or smaller groupings of amino acids. Those amino acids are then either absorbed or broken down further in the small intestine.
* **Trypsin**:[Trypsin](https://www.verywellhealth.com/trypsin-4777708) forms when an enzyme secreted by the pancreas is activated by an enzyme in the small intestine. Trypsin then activates additional pancreatic enzymes, such as carboxypeptidase and chymotrypsin, to help break down peptides.
* **Chymotrypsin**: This enzyme breaks down peptides into free amino acids that can be absorbed by the intestinal wall.
* **Carboxypeptidase A**: Secreted by the pancreas, it splits peptides into individual amino acids.
* **Carboxypeptidase B**:Secreted by the pancreas, it breaks down basic amino acids.

7. Preparations of bee venom

These preparations along with other substances contain the venom of honey bee. Mellittin constitutes 50% of bee venom and consists of 26 amino acids. The remaining part consists of hyaluronidase, phospholipase A and some main polypeptides and histamine. Preparations of bee venom are applid in the form of ointments, liniments, injections in rheumatic diseases of joints and muscles.

8. Inhibitors protease

Natural inhibitors of proteolytic or esterolytic acitivities are widely used in plant and animal world. They are secreted by bacteria, organs and serous fluid of warm-blooded and cold-blooded animals, and legumes (soybean fruits), potatoe, corn and oth. fruits. Their practical significance is to inhibe the proteolytic process.

### 9. Proteilytic Enzymes. Sucrase

Sucrase is secreted by the small intestine, where it breaks down sucrose (the sugar in table sugar) into [fructose](https://www.verywellhealth.com/fructose-malabsorption-and-ibs-1945287) and glucose. These are simpler sugars that the body can absorb.

Sucrase is found along the [intestinal villi](https://www.verywellhealth.com/understanding-intestinal-villi-562555). These are tiny hair-like structures that line the intestine and absorb nutrients into the bloodstream.

**Major digestive enzymes**

Digestive enzymes of mammals are activated in the pancreas and intestine.

1. Pepsin

Pepsin is the proteolytic enzyme, it is obtained from gastric mucosa of pigs, sheep or cattle, it is a pale-yellow coloured powder and administered with lactose. Pepsinogen is secreted by Chief cells in the stomach (molecular weight is 42600), which is converted into active pepsin by an autocatalytic cleavage of peptides (molecular weight is 34500). The optimum ph for pepsin lies between 1,2-3. Pepsin as endopeptidases breaks peptide bonds in the middle of polypeptides. It  is most efficient in cleaving peptide bonds between hydrophobic and preferably aromatic amino acids such as phenylalanine,  tyrosine and oth.) and peptide bonds between aromatic amino acids (for example phenylalanin, tyrosine and oth.). 1 g of crystalline pepsin can cleave 50 of coagulated egg albumin for 2 hours.

Pepsin is perorally administered with hydrochloric acid or combined with other enzymes and the preparations containing pepsin (enzinorm, pansan and oth.).

2. Trypsin

Trypsin is a proteolytic enzyme, it is produced by the pancreas in an inactive form called trypsinogen and it is converted to active trypsin by the mucosa of small intestine, intestinal peptidase and calcium (molecular wreight 24000). It can occur by autocatalytic processing of trypsin. Trypsin is a peptidase consisting of 223 amino-acid molecules and has a high substrate specificity. Trypsin cleaves peptide chains mainly at the carboxyl side of the amino acids lysine and arginine. Trypsin has optimum activity at pH 7-9 in weak-alkaline reaction.

Trypsin is administered as an adjuvant therapy in combination with other intestinal enzymes. It is also used for enzymatic purification of the wound, dissolutin of exudates.

3. Chymotrypsin

Chymotrypsin like trypsin is synthesized by the pancreas as inactive chymotrypsinogen, that is activated only in the small intestine. This enzyme is most active at pH 7,5-8,5. Chymotrypsin cleaves peptide bonds selectively on the carboxylterminal side of the aromatic amino acids.  Chymotripsin enhances the effect of trypsin. That’s why it is used in combination with other enzymes. It is administered locally in ophthalmology practice, promotes wound healing, exerts anti-edema effect.

4. Papain

Papain is a proteolytic enzyme, it cleaves till amino acids, it is obtained from milky sap of an unripe fleshy fruits of papaya (melon tree) - Carica papaya. Papaya grow s to a height of 5-6 m, looks like palm. Its homeland is tropical America. It is cultivated in most tropical countries (South Africa, Sri Lanka and oth.). Papayotin for sale is grayish-white powder, that is obtained by drying the milk sap. Papain can be obtained by fractional salting-out with ammonium sulphate. Papain obtained by this way is 15 times more effective. Papain has a molecular weight of 21000 and consists of 185 structural amino acids. The active center of an enzyme consists of sulfhydryl groups of cysteine and free carboxyl groups of 2 adjacent residues of aspartic acids. Papain usually cleaves peptide bonds of amino acids.

Enzyme papain is included in some medicinal preparations, which exert an action on gastrointestinal tract. Papain is used as an adjuvant therapy to enzymatic digestion, for wound healing (Wobenzym) and in the composition of purification preparations. According to the last data papain and its derivatives are applied in injections to cure damage of intervertebral discs. In food industry papain is used a meat tenderizer.

5. Bromelain and ficin.

Bromelain is a proteolytic enzyme, it is isolated by precipitation from pineapple juice (Ananas comosus). Bromelain corresponds to papain in activity. It is only administered perorally. It is used for the digestive disorders, to reduce swelling after surgery, for the treatment of inflammatory process and as a reagent for the detection of red cell antigen - antibody. Bromelain is included into the following preparations: “Nutrism” and “Esberism”.

Ficin is extracted from the fresh milk sap of several Ficus species (Ficus lamifolia, F. glabrata and oth.). The action for ficin papain and bromelain are similar.

## Digestive Enzyme Deficiencies

There are a variety of health conditions that can interfere with the secretion of enough digestive enzymes to fully digest foods. Some are inherited genetic conditions while others develop over time.

### Lactose Intolerance

Lactose intolerance occurs when you aren't able to digest lactose because of insufficient production of lactase by the small intestine. When you consume dairy products, you may experience:

* Bloating
* Diarrhea
* [Abdominal pain](https://www.verywellhealth.com/abdominal-pain-when-to-see-a-doctor-1745398)
* Gas3

There are several forms of lactose intolerance.

### Congenital Lactase Deficiency

Congenital lactase deficiency (also called congenital alactasia) is a rare inherited form of lactose intolerance. It happens when newborns are unable to break down lactose in breast milk or formula. They get severe diarrhea if they aren't given a lactose-free alternative.

Congenital lactase deficiency is caused by mutations in the LCT gene that provides instructions for making the lactase enzyme.5

### Lactase Non-Persistence

Lactase non-persistence is a common type of lactose intolerance that some people develop as adults. It affects around 65% of people, and it's caused by decreased expression (activity) of the LCT gene. Symptoms typically begin 30 minutes to two hours after eating or drinking dairy.3

Most people with lactase non-persistence keep some level of lactase activity and can continue to include a small amount of lactose in their diets. This may be in the form of cheese or yogurt since both tend to be tolerated better than fresh milk.

### Secondary Lactose Intolerance

Secondary lactose intolerance develops when lactase production is reduced because of diseases that can damage the small intestine. These diseases include [celiac disease](https://www.verywellhealth.com/celiac-disease-overview-4581991) or Crohn's disease as well as other illnesses or injuries that affect the intestinal wall.

### Exocrine Pancreatic Insufficiency

The pancreas produces the key digestive enzymes amylase, protease, and lipase. People with [exocrine pancreatic insufficiency](https://www.verywellhealth.com/exocrine-pancreatic-insufficiency-4177936) (EPI) have a deficiency of these enzymes. As a result, they are unable to digest food properly, especially fats.

The health conditions that affect the pancreas and are associated with EPI are:

* **Chronic pancreatitis**: An inflammation of the pancreas that can permanently damage the organ over time
* [**Cystic fibrosis**](https://www.verywellhealth.com/cystic-fibrosis-4014739): Aninherited genetic condition that causes severe damage to the lungs and digestive system, including the pancreas6
* **Pancreatic cancer**

## Foods High in Digestive Enzymes

A variety of foods, especially tropical fruits and fermented vegetables, are naturally high in digestive enzymes that might speed up the digestion of certain nutrients.

It's best to eat them raw since heat can lessen or destroy these plant enzymes.

| **Foods with Digestive Enzymes** | | |
| --- | --- | --- |
| **Food** | **Enzymes** | **Benefit** |
| Pineapple | Proteases (bromelain) | Helps digest proteins and has additional anti-inflammatory effects |
| Papaya | Proteases (papain) | Helps digest proteins and is a popular meat tenderizer |
| Kiwi | Proteases (actinidain) | In addition to its digestive enzymes, the fruit is high in fiber to support digestive tract function |
| Mango | Amylases | Helps break down carbohydrates from starches into simple sugars and increases as the fruit ripens |
| Banana | Amylases,  glucosidases | Like amylases, glucosidases also break down complex carbohydrates |
| Raw honey | Amylases, Diastases, invertases, proteases | The amylases and diastases help to break down starches, invertases break down sugars, and proteases break down protein |
| Avocado | Lipases | Helps digest and metabolize fat |
| Kefir | Lipases, lactase, proteases | The lactase in kefir helps to digest the fermented milk and may be tolerated by some people with lactose intolerance |
| Sauerkraut, kimchi | Lipases, proteases | Fermented foods develop enzymes during the fermentation process as well as probiotics, or beneficial bacteria, to further support digestive health |
| Miso | Lactases, lipases, proteases, amylases | This fermented soy paste contains a potent combination of enzymes that help break down lactose in dairy, fats, proteins, and carbohydrates |
| Ginger | Protease (zingibain) | In addition to its enzymes that can help break down proteins, ginger may also help ease nausea |

Digestive juices require hydration, so make sure that you drink water throughout the day.

## Digestive Enzyme Supplements

People who don't have sufficient amounts of digestive enzymes or who are looking to support healthy digestion should consider supplementing their diet with digestive enzymes.

They can do this by eating healthy foods that contain naturally occurring digestive enzymes. But they can also take [nutritional supplements](https://www.verywellhealth.com/best-digestive-enzymes-4688740) under a healthcare provider's guidance.

Digestive enzyme supplements can come in:

* Pills
* Powders
* Liquids sourced from animals, plants, or microbes

There are prescription supplements regulated by the FDA as well as over-the-counter supplements.

### Prescription Supplements

Prescription enzyme supplements are recommended for conditions that affect the functioning of the pancreas, such as chronic pancreatitis or pancreatic cancer.

Brands of prescription pancreatic enzyme supplements (pancrelipase) include:7

* Creon
* Pancreaze
* Zenpep
* Ultresa
* Viokace
* Pertzye

### Over-the-Counter Supplements

Over-the-counter enzyme supplements are not regulated by the FDA. There haven't been enough high-quality studies on them, so it's hard to know how effective they are.

The following are some of the supplemental enzymes that don't require a prescription:

* Lactase supplements may help people who are lactose intolerant to digest dairy products and are available as tablets or drops.8
* [Bromelain](https://www.verywellhealth.com/bromelain-what-should-you-know-about-it-88318) is a powerful protease from the fruit or stem of pineapples that comes in capsule, tablet, or powder form and may help with the digestion of protein.9
* Papain from papaya may help with digesting proteins, and the powder form can be used as a meat tenderizer.

As with any supplement, check with your healthcare provider before taking an over-the-counter digestive enzyme to make sure it's safe for you.

**Pineapple -** [**Ananas comosus**](https://en.wikipedia.org/wiki/Ananas_comosus)**(L.)**

**Family: Bromeliaceae**

Ananas is a plant [genus](https://en.wikipedia.org/wiki/Genus) in the family [Bromeliaceae](https://en.wikipedia.org/wiki/Bromeliaceae" \o "Bromeliaceae). It is native to [South America](https://en.wikipedia.org/wiki/South_America) and includes the species Ananas comosus, the [pineapple](https://en.wikipedia.org/wiki/Pineapple).

The genus Ananas includes only two species: [Ananas comosus](https://en.wikipedia.org/wiki/Ananas_comosus) (L.) or Pineapple ( East of the Andes, from northern South America to northern Argentina) and [Ananas macrodontes](https://en.wikipedia.org/wiki/Ananas_macrodontes) E.Morren or False Pineapple (Coastal Brazil and basins of Parana and Paraguay rivers to northern Argentina.)

Part used. Fructus ananasi, The pineapple (Ananas comosus) is a tropical plant with an edible fruit, also called a pineapple, and the most economically significant plant in the family [Bromeliaceae](https://en.wikipedia.org/wiki/Bromeliaceae" \o "Bromeliaceae).

Habitat- pineapples may be cultivated from the [offset](https://en.wikipedia.org/wiki/Offset_(botany)) produced at the top of the fruit, possibly flowering in five to ten months and fruiting in the following six months. Pineapples do not ripen significantly after harvest. In 2016, Costa Rica, Brazil, and the Philippines accounted for nearly one-third of the world's production of pineapples.

Plant. - The pineapple is a [herbaceous](https://en.wikipedia.org/wiki/Herbaceous_plant) [perennial](https://en.wikipedia.org/wiki/Perennial), which grows to 1.0 to 1.5 m (3.3 to 4.9 ft) tall, although sometimes it can be taller. In appearance, the plant has a short, stocky stem with tough, waxy leaves. When creating its fruit, it usually produces up to 200 flowers, although some large-fruited cultivars can exceed this. Once it flowers, the individual fruits of the flowers join together to create a [multiple fruit](https://en.wikipedia.org/wiki/Multiple_fruit). After the first fruit is produced, side shoots (called 'suckers' by commercial growers) are produced in the leaf axils of the main stem. These may be removed for propagation, or left to produce additional fruits on the original plant. Commercially, suckers that appear around the base are cultivated. It has 30 or more long, narrow, fleshy, trough-shaped leaves with sharp spines along the margins that are 30 to 100 cm (1.0 to 3.3 ft) long, surrounding a thick [stem](https://en.wikipedia.org/wiki/Plant_stem). In the first year of growth, the axis lengthens and thickens, bearing numerous leaves in close spirals. After 12 to 20 months, the stem grows into a spike-like inflorescence up to 15 cm (6 in) long with over 100 spirally arranged, trimerous flowers, each subtended by a bract.

The ovaries develop into [berries](https://en.wikipedia.org/wiki/Berry_(botany)), which coalesce into a large, compact, multiple fruit. The fruit of a pineapple is arranged in two interlocking helices, eight in one direction, 13 in the other, each being a [Fibonacci number](https://en.wikipedia.org/wiki/Fibonacci_number#Fibonacci_numbers_in_nature).

Constituents. – The pineapple carries out [CAM photosynthesis](https://en.wikipedia.org/wiki/Crassulacean_acid_metabolism), fixing carbon dioxide at night and storing it as the acid [malate](https://en.wikipedia.org/wiki/Malate), then releasing it during the day aiding photosynthesis.

Raw pineapple pulp is 86% water, 13% [carbohydrates](https://en.wikipedia.org/wiki/Carbohydrate), 0.5% [protein](https://en.wikipedia.org/wiki/Protein), and contains negligible [fat](https://en.wikipedia.org/wiki/Fat) (table). In a 100-gram reference amount, raw pineapple supplies 50 [calories](https://en.wikipedia.org/wiki/Calorie), and is a rich source of [manganese](https://en.wikipedia.org/wiki/Manganese) (44% [Daily Value](https://en.wikipedia.org/wiki/Dietary_Reference_Intake), DV) and [vitamin C](https://en.wikipedia.org/wiki/Vitamin_C) (58% DV), but otherwise contains no [micronutrients](https://en.wikipedia.org/wiki/Micronutrient) in significant amounts.

Pineapple fruits and peels contain diverse [phytochemicals](https://en.wikipedia.org/wiki/Phytochemical), among which are [polyphenols](https://en.wikipedia.org/wiki/Polyphenol), including [gallic acid](https://en.wikipedia.org/wiki/Gallic_acid), [syringic acid](https://en.wikipedia.org/wiki/Syringic_acid), [vanillin](https://en.wikipedia.org/wiki/Vanillin), [ferulic acid](https://en.wikipedia.org/wiki/Ferulic_acid), [sinapic acid](https://en.wikipedia.org/wiki/Sinapic_acid" \o "Sinapic acid), [coumaric acid](https://en.wikipedia.org/wiki/Coumaric_acid), [chlorogenic acid](https://en.wikipedia.org/wiki/Chlorogenic_acid), [epicatechin](https://en.wikipedia.org/wiki/Epicatechin), and [arbutin](https://en.wikipedia.org/wiki/Arbutin).

Bromelain

Present in all parts of the pineapple plant, [bromelain](https://en.wikipedia.org/wiki/Bromelain) is a mixture of [proteolytic](https://en.wikipedia.org/wiki/Proteolytic) [enzymes](https://en.wikipedia.org/wiki/Enzyme). Bromelain is under preliminary research for a variety of clinical disorders, but to date has not been adequately defined for its effects in the human body. Bromelain may be unsafe for some users, such as in [pregnancy](https://en.wikipedia.org/wiki/Pregnancy), [allergies](https://en.wikipedia.org/wiki/Allergies), or [anticoagulation](https://en.wikipedia.org/wiki/Anticoagulation) therapy.

Bromelain is an [enzyme](https://en.wikipedia.org/wiki/Enzyme) extract derived from the [stems](https://en.wikipedia.org/wiki/Plant_stem) of [pineapples](https://en.wikipedia.org/wiki/Pineapple), although it exists in all parts of the fresh pineapple. The extract has a history of [folk medicine](https://en.wikipedia.org/wiki/Folk_medicine) use. As an ingredient, it is used in [cosmetics](https://en.wikipedia.org/wiki/Cosmetics), as a [topical medication](https://en.wikipedia.org/wiki/Topical_medication), and as a [meat tenderizer](https://en.wikipedia.org/wiki/Meat_tenderizer).

While there have been studies which correlated the use of bromelain with reduction of symptom severity in [osteoarthritis](https://en.wikipedia.org/wiki/Osteoarthritis), "[t]he majority of the studies have methodological issues that make it difficult to draw definite conclusions", as none definitively established efficacy, recommended dosage, long term safety, or adverse interaction with other medications. Bromelain has been studied as an [antithrombotic](https://en.wikipedia.org/wiki/Antithrombotic) and [anti-inflammatory](https://en.wikipedia.org/wiki/Anti-inflammatory)agent in the treatment of [cardiovascular disease](https://en.wikipedia.org/wiki/Cardiovascular_disease), and a 2012 review suggests that it may have other properties for therapeutic treatment, but all of these possible effects remain unconfirmed and under preliminary research.

A concentrate of proteolytic enzymes enriched in bromelain is approved in Europe for the [debridement](https://en.wikipedia.org/wiki/Debridement) (removal of dead tissue) of severe [burn](https://en.wikipedia.org/wiki/Burn) wounds under the trade name [NexoBrid](https://en.wikipedia.org/wiki/NexoBrid" \o "NexoBrid). Systemic enzyme therapy (consisting of combinations of proteolytic enzymes such as bromelain, trypsin, [chymotrypsin](https://en.wikipedia.org/wiki/Chymotrypsin), and papain) has been investigated in Europe to evaluate the efficacy in breast, colorectal, and [plasmacytoma](https://en.wikipedia.org/wiki/Plasmacytoma) cancer patients. Bromelain may be effective as an [adjunct therapy](https://en.wikipedia.org/wiki/Adjunct_therapy) in relieving symptoms of acute [rhinosinusitis](https://en.wikipedia.org/wiki/Rhinosinusitis) in patients not treated with [antibiotics](https://en.wikipedia.org/wiki/Antibiotics). Bromelain is also claimed as a tooth plaque removal enhancer in toothpastes.

The flesh and juice of the pineapple are used in cuisines around the world.

Papaya - Carica papaya

[Caricaceae](https://en.wikipedia.org/wiki/Caricaceae) family

The papaya ([/pəˈpaɪə/](https://en.wikipedia.org/wiki/Help:IPA/English), [US](https://en.wikipedia.org/wiki/American_English): [/pəˈpɑːjə/](https://en.wikipedia.org/wiki/Help:IPA/English)) (from [Carib](https://en.wikipedia.org/wiki/Carib_language) via Spanish), papaw or pawpaw is the [plant](https://en.wikipedia.org/wiki/Plant) Carica papaya, one of the 22 accepted species in the [genus](https://en.wikipedia.org/wiki/Genus) [Carica](https://en.wikipedia.org/wiki/Carica" \o "Carica) of the family [Caricaceae](https://en.wikipedia.org/wiki/Caricaceae" \o "Caricaceae). Its origin is in the tropics of the [Americas](https://en.wikipedia.org/wiki/Americas), perhaps from southern [Mexico](https://en.wikipedia.org/wiki/Mexico) and neighboring [Central America](https://en.wikipedia.org/wiki/Central_America).

Part used. Papaya skin, pulp and seeds.

Habitat. [Native](https://en.wikipedia.org/wiki/Native_plant) to Mexico and northern [South America](https://en.wikipedia.org/wiki/South_America), papaya has become [naturalized](https://en.wikipedia.org/wiki/Naturalisation_(biology)) through out the [Caribbean Islands](https://en.wikipedia.org/wiki/Caribbean_Islands), [Florida](https://en.wikipedia.org/wiki/Florida), [Texas](https://en.wikipedia.org/wiki/Texas), [California](https://en.wikipedia.org/wiki/California), [Hawaii](https://en.wikipedia.org/wiki/Hawaii), and other [tropical](https://en.wikipedia.org/wiki/Tropics) and [subtropical](https://en.wikipedia.org/wiki/Subtropical) regions of the world

Plant. The papaya is a small, sparsely branched tree, usually with a single [stem](https://en.wikipedia.org/wiki/Plant_stem) growing from 5 to 10 m (16 to 33 ft) tall, with spirally arranged [leaves](https://en.wikipedia.org/wiki/Leaf) confined to the top of the [trunk](https://en.wikipedia.org/wiki/Trunk_(botany)). The lower trunk is conspicuously [scarred](https://en.wikipedia.org/wiki/Scar" \o "Scar)where leaves and fruit were borne. The leaves are large, 50–70 cm (20–28 in) in [diameter](https://en.wikipedia.org/wiki/Diameter), deeply [palmately](https://en.wikipedia.org/wiki/Glossary_of_leaf_shapes) lobed, with seven lobes. All parts of the plant contain [latex](https://en.wikipedia.org/wiki/Latex) in articulated laticifers. Papayas are [dioecious](https://en.wikipedia.org/wiki/Dioecious). The [flowers](https://en.wikipedia.org/wiki/Flower) are 5-parted and highly dimorphic, the male flowers with the stamens fused to the petals. The female flowers have a superior ovary and five contorted petals loosely connected at the base. Male and female flowers are borne in the leaf axils, the males in multiflowered [dichasia](https://en.wikipedia.org/wiki/Glossary_of_botanical_terms#Dichasium), and the female flowers in few-flowered [dichasia](https://en.wikipedia.org/wiki/Dichasia). The pollen grains are elongated and approximately 35 microns in length. The flowers are sweet-scented, open at night, and are wind- or insect-pollinated.

The fruit is a large [berry](https://en.wikipedia.org/wiki/Berry_(botany)) about 15–45 cm (5.9–17.7 in) long and 10–30 cm (3.9–11.8 in) in diameter. It is [ripe](https://en.wikipedia.org/wiki/Ripening) when it feels soft (as soft as a ripe [avocado](https://en.wikipedia.org/wiki/Avocado) or softer), and its skin has attained an amber to orange hue

Constituents. – Raw papaya pulp contains 88% water, 11% [carbohydrates](https://en.wikipedia.org/wiki/Carbohydrates), and negligible [fat](https://en.wikipedia.org/wiki/Fat) and [protein](https://en.wikipedia.org/wiki/Protein)(table). In a 100 gram amount, papaya fruit provides 43 [kilocalories](https://en.wikipedia.org/wiki/Calories) and is a significant source of [vitamin C](https://en.wikipedia.org/wiki/Vitamin_C) (75% of the [Daily Value](https://en.wikipedia.org/wiki/Daily_Value), DV) and a moderate source of [folate](https://en.wikipedia.org/wiki/Folate) (10% DV), but otherwise has low content of [nutrients](https://en.wikipedia.org/wiki/Nutrients) (see table).

Papaya skin, pulp and seeds contain a variety of [phytochemicals](https://en.wikipedia.org/wiki/Phytochemical), including [carotenoids](https://en.wikipedia.org/wiki/Carotenoid) and [polyphenols](https://en.wikipedia.org/wiki/Polyphenol), as well as [benzyl isothiocyanates](https://en.wikipedia.org/wiki/Benzyl_isothiocyanate) and benzyl glucosinates, with skin and pulp levels that increase during ripening. Papaya seeds also contain the [cyanogenic](https://en.wikipedia.org/wiki/Cyanogenic) substance [prunasin](https://en.wikipedia.org/wiki/Prunasin" \o "Prunasin). Papain contains substances called [enzymes](https://www.rxlist.com/script/main/art.asp?articlekey=15392) that help break down [proteins](https://www.rxlist.com/script/main/art.asp?articlekey=15380)

MPM. - Papain is usually produced as a crude, dried material by collecting the [latex](https://en.wikipedia.org/wiki/Latex) from the fruit of the papaya tree. The latex is collected after scoring the neck of the fruit, where it may either dry on the fruit or drip into a container. This latex is then further dried. It is now classified as a dried, crude material. A purification step is necessary to remove contaminating substances. This purification consists of the solubilization and extraction of the active papain enzyme system through a government-registered process. This purified papain may be supplied as powder or as liquid.

Pharmacological Action Uses. - In [traditional medicine](https://en.wikipedia.org/wiki/Traditional_medicine), papaya leaves have been used as a treatment for [malaria](https://en.wikipedia.org/wiki/Malaria), an [abortifacient](https://en.wikipedia.org/wiki/Abortifacient), a [purgative](https://en.wikipedia.org/wiki/Laxative), or smoked to relieve [asthma](https://en.wikipedia.org/wiki/Asthma).

Papaya releases a [latex](https://en.wikipedia.org/wiki/Latex) fluid when not ripe, possibly causing irritation and an allergic reaction in some people. Because the enzyme papain acts as an [allergen](https://en.wikipedia.org/wiki/Allergen) in sensitive individuals, meat that has been tenderized with it may induce an [allergic reaction](https://en.wikipedia.org/wiki/Allergic_reaction).

Papain is used for [pain](https://www.rxlist.com/script/main/art.asp?articlekey=4723) and swelling ([inflammation](https://www.rxlist.com/script/main/art.asp?articlekey=3979)) as well as fluid retention following [trauma](https://www.rxlist.com/script/main/art.asp?articlekey=8171) and [surgery](https://www.rxlist.com/script/main/art.asp?articlekey=5603). It is used as a digestive aid and for treating [parasitic](https://www.rxlist.com/script/main/art.asp?articlekey=11869) worms, inflammation of the [throat](https://www.rxlist.com/script/main/art.asp?articlekey=53392) and [pharynx](https://www.rxlist.com/script/main/art.asp?articlekey=4863), [shingles](https://www.rxlist.com/script/main/art.asp?articlekey=5476) ([herpes zoster](https://www.rxlist.com/script/main/art.asp?articlekey=3734)) symptoms, ongoing [diarrhea](https://www.rxlist.com/script/main/art.asp?articlekey=2985), [hay fever](https://www.rxlist.com/script/main/art.asp?articlekey=3656), [runny nose](https://www.rxlist.com/script/main/art.asp?articlekey=5400), and a [skin](https://www.rxlist.com/script/main/art.asp?articlekey=7901) [condition](https://www.rxlist.com/script/main/art.asp?articlekey=10778) called [psoriasis](https://www.rxlist.com/script/main/art.asp?articlekey=5104). Papain is also used along with conventional treatments for tumors.

Some people apply papain directly to the skin to treat infected wounds, sores, and ulcers.

[In](https://www.rxlist.com/script/main/art.asp?articlekey=3950) manufacturing, papain is used in cosmetics, toothpaste, enzymatic soft contact [lens](https://www.rxlist.com/script/main/art.asp?articlekey=7850) cleaners, meat tenderizers, and meat products. It is also used for stabilizing and chill-proofing beer.

***Zingiber officinale***

**Botanical origin. –** *Zingiber officinale* (Eng. Ginger). Family – *Zingiberaceae.*

**Part used.** – Rhizoma Zingiberis

**Habitat. -** Ginger originated from [Island Southeast Asia](https://en.wikipedia.org/wiki/Island_Southeast_Asia). It is a true [cultigen](https://en.wikipedia.org/wiki/Cultigen) and does not exist in its wild state. Ginger was carried with them in their voyages as [canoe plants](https://en.wikipedia.org/wiki/Canoe_plant) during the [Austronesian expansion](https://en.wikipedia.org/wiki/Austronesian_expansion), starting from around 5,000 [BP](https://en.wikipedia.org/wiki/Before_Present). They introduced it to the [Pacific Islands](https://en.wikipedia.org/wiki/Pacific_Island) in prehistory, long before any contact with other civilizations.  From India, it was also carried by traders into the [Middle East](https://en.wikipedia.org/wiki/Middle_East) and the [Mediterranean](https://en.wikipedia.org/wiki/Mediterranean) by around the [1st century CE](https://en.wikipedia.org/wiki/1st_century_CE). It was primarily grown in [southern India](https://en.wikipedia.org/wiki/Southern_India) and the [Greater Sunda Islands](https://en.wikipedia.org/wiki/Greater_Sunda_Islands) during the [spice trade](https://en.wikipedia.org/wiki/Spice_trade), along with [peppers](https://en.wikipedia.org/wiki/Piper_(genus)), [cloves](https://en.wikipedia.org/wiki/Clove), and numerous other spices.

**Plant. -** Ginger is a [flowering plant](https://en.wikipedia.org/wiki/Flowering_plant) whose [rhizome](https://en.wikipedia.org/wiki/Rhizome), ginger root or ginger, is widely used as a [spice](https://en.wikipedia.org/wiki/Spice) and a [folk medicine](https://en.wikipedia.org/wiki/Folk_medicine). It is a [herbaceous](https://en.wikipedia.org/wiki/Herbaceous) [perennial](https://en.wikipedia.org/wiki/Perennial_plant) which grows annual pseudostems (false stems made of the rolled bases of leaves) about a meter tall bearing narrow leaf blades. The [inflorescences](https://en.wikipedia.org/wiki/Inflorescence) bear pale yellow with purple flowers and arise directly from the rhizome on separate shoots.

**MPM Description. -** Ginger produces [clusters](https://en.wikipedia.org/wiki/Inflorescence) of white and pink [flower buds](https://en.wikipedia.org/wiki/Flower_bud) that bloom into yellow flowers. It is a [perennial](https://en.wikipedia.org/wiki/Perennial) [reed](https://en.wikipedia.org/wiki/Reed_bed)-like plant with annual leafy stems, about a meter (3 to 4 feet) tall. Traditionally, the rhizome is gathered when the stalk [withers](https://en.wiktionary.org/wiki/wither); it is immediately [scalded](https://en.wiktionary.org/wiki/Special:Search/scald), or washed and scraped, to kill it and prevent [sprouting](https://en.wikipedia.org/wiki/Sprouting). The fragrant [perisperm](https://en.wikipedia.org/wiki/Perisperm) of the Zingiberaceae is used as [sweetmeats](https://en.wikipedia.org/wiki/Sweetmeat) by [Bantu](https://en.wikipedia.org/wiki/Bantu_peoples), and also as a condiment and [sialagogue](https://en.wikipedia.org/wiki/Sialagogue).

**Consitutuents. -** The characteristic fragrance and flavor of ginger result from [volatile](https://en.wikipedia.org/wiki/Volatility_(chemistry)) [oils](https://en.wikipedia.org/wiki/Essential_oil) that compose 1-3% of the weight of fresh ginger, primarily consisting of [zingerone](https://en.wikipedia.org/wiki/Zingerone), [shogaols](https://en.wikipedia.org/wiki/Shogaol) and [gingerols](https://en.wikipedia.org/wiki/Gingerol) with [6]-gingerol (1-[4'-hydroxy-3'-methoxyphenyl]-5-hydroxy-3-decanone) as the major pungent compound.[Zingerone is produced from gingerols during drying, having lower pungency and a spicy-sweet aroma. Shagoals are more pungent and have higher antioxidant activity but not found in raw ginger, but is formed from gingerols during heating, storage or via acidity. Fresh ginger also contains an enzyme [zingibain](https://en.wikipedia.org/wiki/Zingibain" \o "Zingibain) which is a [cysteine protease](https://en.wikipedia.org/wiki/Cysteine_protease) and has similar properties to [rennet](https://en.wikipedia.org/wiki/Rennet).

**Pharmacological Action Uses**. - Evidence that ginger helps alleviate [nausea](https://en.wikipedia.org/wiki/Nausea) and vomiting resulting from [chemotherapy](https://en.wikipedia.org/wiki/Chemotherapy-induced_nausea_and_vomiting) or pregnancy is inconsistent. There is no clear evidence of harm from taking ginger during pregnancy, although its safety has not been established.Ginger is not effective for treating [dysmenorrhea](https://en.wikipedia.org/wiki/Dysmenorrhea" \o "Dysmenorrhea),and there is insufficient evidence for it having [analgesic](https://en.wikipedia.org/wiki/Analgesia) properties due to the lack of well conducted trials. Available data provides weak evidence for its anti-inflammatory role and it may reduce the subjective experience of pain in [osteoarthritis](https://en.wikipedia.org/wiki/Osteoarthritis).

[Allergic reactions](https://en.wikipedia.org/wiki/Allergic_reaction) to ginger generally result in a [rash](https://en.wikipedia.org/wiki/Rash" \o "Rash).Although [generally recognized as safe](https://en.wikipedia.org/wiki/Generally_recognized_as_safe), ginger can cause [heartburn](https://en.wikipedia.org/wiki/Heartburn) and other side effects, particularly if taken in powdered form.[]](https://en.wikipedia.org/wiki/Ginger#cite_note-nccih-2) It may adversely affect individuals with [gallstones](https://en.wikipedia.org/wiki/Gallstone) and may interfere with the effects of [anticoagulants](https://en.wikipedia.org/wiki/Anticoagulant), such as [warfarin](https://en.wikipedia.org/wiki/Warfarin) or [aspirin](https://en.wikipedia.org/wiki/Aspirin).

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