Enzymes in Food Systems

Activity #1

Testing for Catalase Activity

A Science Unit for Secondary School Curriculum



TEACHER INFORMATION SHEET

Testing for Catalase Activity

The chemical reactions that occur in living cells are complex and highly controlled. Certain chemicals accelerate reactions without being changed themselves. These outside agents are called *catalysts*, and the rate acceleration caused by such substances is called *catalysis*.

Practically all biological reactions involve the use of specialized catalysts called *enzymes*. Enzymes are produced naturally in plant, animal, and microbial cells, and thousands of different enzymes can be found in any cell. Because each enzyme has a very specific function in the cell and is not used up during the reaction, only low concentrations need to be present to achieve a desired effect.

Enzymes have been of major importance since ancient times, when they were first used in the production of wines, cheeses, and other foods and beverages. Since the mechanisms of enzyme action were not yet known, the control of these enzymatic reactions was based exclusively on practical experience. However, recent understanding of the properties, production, and application of enzymes has changed enzymatic processing from an art to a science.

CLASSES OF ENZYMES

Enzymes can be classified by the type of substance they affect. Proteases (P) react with proteins, lipases (L) with lipids (fats), and carbohydrases (C) with carbohydrates (sugars and starches). Other enzymes (O) react with a variety of other substrates (Visual Master 1).

SOME DESIRABLE CHANGES PRODUCED BY ENZYMES

- Formation of cheese curd by rennin (P)
- Meat tenderizing by papain, bromelin, microbial protease (P)
- Contact-lens cleaning by microbial protease (P)
- Protein digestion by pepsin, trypsin (P)
- Development of flavor in cheeses by lipase, esterase (L)
- Increased loaf volume in bread by amylase (C)
- Prevention of staling in bread by amylase (C)
- Fruit ripening by polygalacturonase (C)
- Removal of fruit juice from pulp by pectinase (C)
- Production of soft center in chocolate covered cherries by invertase (C)
- Production of beer by amylase, glucoamylase, protease (C, P)
- Production of light beer by amylase (C)
- Debittering of fruit juices by naringinase (O)

- Production of low- and no-lactose dairy products (for persons with lactose intolerance) by lactase (C)
- Starch digestion by salivary amylase (C)
- Clarifying of juice drinks by amylase (C)
- Prevention of sloughing in canned green beans by pectin methylesterase (C)

SOME UNDESIRABLE CHANGES PRODUCED BY ENZYMES

- Rotting of foods by protease (P)
- Development of rancidity in fats by microbial lipase (L)
- Over-ripening of fruits by polygalacturonase (C)
- Softening of unblanched vegetables by peroxidase (O)
- Development of off-flavors and off-odors in unblanched vegetables by catalase, lipoxygenase (O)
- Browning of certain fruit and vegetable slices by polyphenolase (O)

ACTION OF ENZYMES

Substrate + Enzyme

← Substrate-Enzyme Complex

← Product + Enzyme

In an enzyme-catalyzed reaction, the enzyme joins with the substrate (a reactant in a chemical reaction) and helps transform the substrate into the product. For example, the enzyme amylase joins with a starch molecule and helps break down the starch into its component sugars. The enzyme is a catalyst, which means that it participates in the reaction but is not used up during the reaction. Enzymes are complex proteins, and each enzyme has a specific structure designed to work with a particular reaction. Like all proteins, enzymes contain chains of amino acids which are arranged in a specific three-dimensional pattern held together by a variety of chemical forces. A small portion of the enzyme, known as the active site, binds to the substrate.

Figure 1 (Visual Master 2) illustrates the two simple models which explain how the active site of an enzyme can bind specifically to a particular substrate. The first is the *Lock-and-Key model*. This model assumes that the substrate fits into the active site much like a key fits into a lock or the pieces of a jigsaw puzzle interlock. The second is the *Induced-Fit model*. This model assumes that the active site of the enzyme is modified by interaction with the substrate so that the enzyme can mold around the substrate for an appropriate fit.

FACTORS AFFECTING ENZYME ACTIVITY

By following the amount of product formed in a specified period of time, the activity or effectiveness of the enzyme can be assessed quantitatively. As shown in Figure 2 (Visual Master 2), the amount of product formed increases if the concentration of substrate is increased, until there is an excess level of substrate present.

Since enzymes are complex proteins, any factors which affect protein structure will also affect enzyme activity. These factors include pH, temperature, and the presence of other compounds. An enzyme-catalyzed reaction can be speeded up, slowed down, or even stopped by changing any of these factors. In general, enzyme activity doubles for every 10°C rise in temperature until the enzyme is inactivated, at which point the activity drops sharply (Figure 3, Visual Master 3). The "temperature optimum" will vary depending on the amount of time the enzyme is allowed to remain at a specific temperature. What would you suppose is the optimum temperature for enzymes in the human body?

Temperature is often used to control enzyme activity. Vegetables, whole or sliced, are blanched prior to freezing to inactivate catalase, peroxidase, and lipoxygenase enzymes responsible for softening or the development of off-flavors and off-odors. Fruits and vegetables are refrigerated to decrease the rate of browning catalyzed by the enzyme polyphenolase.

Each enzyme has an optimum pH range for activity and also for stability (Figure 4, Visual Master 3). For example, an enzyme which catalyzes the breakdown of protein in the acidic environment of your stomach might have an optimum pH of 2. In the basic environment of the small intestine, the optimum pH of the enzymes will be about 8. Would you expect an enzyme that is used with a citrus fruit to have an acidic or basic pH optimum?

Enzymes are named after their substrates or their type of reaction. Nearly all enzymes have names that end in -ase. The prefix is either from the type of reaction or from the name of the substrate. For example, a hydrolase catalyzes hydrolysis reactions, and lipase and chlorophyllase catalyze the hydrolysis of lipids and chlorophyll, respectively.