# Introduction to Food Science and Engineering

## Food Constituent: Proteins and Enzyme

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# Proteins and Enzymes

**Protein:** Proteins are the polymers of amino acids linked together by peptide bond with molecular weights ranging from around 10,000 to several hundred thousand.

- Proteins are the most abundant organic molecules of the living system and constitute about 50% of the cellular dry matter.
- Proteins are of importance in human food with respect to two aspects namely nutrition and desired textural quality of food.
- Protein imbalance in food leads to malnutrition.

**Enzymes:** Enzymes are proteins with a special function namely biocatalysis.

# Classification of Proteins

A. Classification of protein: Proteins can be classified into three (3) groups according to their structures.

1. Simple protein: contain only amino acids.

   Example: albumin, globulin, glutelin.

1. Conjugated protein: contain non-protein substances in addition to amino acid.

   Example: lipoprotein, glycoprotein, phosphoprotein.

1. Derived protein: produced from simple and conjugated protein.

   Example: peptone, peptide, polypeptide.

# Classification of Proteins

B. Classification of protein: Proteins can also be classified into two groups on the basis of their nutritional value.

1. First class proteins:

- They are of high nutritional value,
- Contain all the essential amino acids,
- They are found from animal sources,
- Examples: milk, egg, meat, fish.

2. Second class protein:

- They are of low nutritional value,
- Do not contain all the essential amino acids,
- The are found from plant sources.
- Examples: pulse, nuts, cereals.

# Complementary Action of protein

Complementary action of protein: When two or more second class proteins are mixed together, they can compensate each others' deficiency and act as a first class protein.

For example: Rice and Pulse are second class protein. But they can be first class protein when they are mixed together (khichori).

# Classification of Proteins

**C. Classification: Proteins may also be classified into eight groups depending on their functional role in biological system.**

1. **Catalytic protein (Enzymes): Enzymes** are biocatalysts.
2. **Contractile protein: Helps in muscle contraction. E.g. actin, myosin,**
3. **Carrier proteins:** Carrier proteins control the transport of substances, e.g. haemoglobin (transport oxygen) and lipoprotein (transport lipid).
4. **Protective protein: e.g. Immunoglobulins** form antibodies that provide an animal's defence against invading microorganisms.
5. **Structural proteins: Proteins that** provide structure of the cells. e.g. collagen (skin), keratin (hair, nail).
6. Regulatory protein: hormonal proteins regulate different body functions. e.g. Growth hormone causes growth of body, insulin hormone regulate blood glucose level.

# Classification of protein (contd)

7. Storage protein: ferritin stores iron in liver, Myoglobin stores oxygen in muscle.

8. Receptor protein: Enable cell to respond to hormone and drugs. e.g. insulin receptor.

# Elemental Composition of Proteins

- Proteins are predominantly constituted by five major elements in the following proportion.

| Elements | Ranges in Percentage |
|---|---|
| Carbon | 50 - 55 |
| Hydrogen | 6 -7.3 |
| Oxygen | 19 - 24 |
| Nitrogen | 13 - 19 |
| Sulfur | 0 - 4 |

Besides these, proteins may also contain other elements such as P, Fe, Cu, I, Mg, Mn, Zn etc. at various proportions.

**Estimation of Nitrogen:** The content of nitrogen, an essential component of proteins, on an average is 16%. Estimation of nitrogen in the laboratory (mostly by Kjeldahl's Method) is also used to find out the amount of protein in biological fluids and foods.

# Function/Role of Protein in Biological System

1. Proteins are the source of dietary amino acids and are used for growth and maintenance of living system. Protein imbalance in food leads to malnutrition.
2. Proteins are primarily responsible for structure and strength of body.
3. Proteins are the major constituents of tissues and proteins in our diet provide the amino acids from which body synthesizes its own proteins.
4. The action of hydrolytic enzymes in the stomach as well as the small intestine breaks down food proteins to their component amino acids. On absorption into the blood stream they become part of the amino acid pool of the body. The amino acid pool is used for protein synthesis.
5. Non-essential amino acids can be synthesized by Mammals if adequate amount of amino nitrogen and carbohydrates are available.
6. Essential amino acids can not be synthesized and hence must be supplied in the diet. EAAs include methionine, tryptophan, threonine, valine, phenyl alanine, isoleucine, leucine, lysine, arginine, histidine,
7. Ideally, the protein in the diet should provide the amino acids in the same relative proportions as the body's requirement. Absence of even one particular amino acid will result in cessation of all protein synthesis

# Dietary Protein Requirement

**Protein Requirement**: Protein requirement (unlike carbohydrates and fats) on the basis of human body weight varies only slightly with increasing age above 20 years. The recommended daily amount of protein for different age groups are given in a table below.

**Table. Recommended daily requirement of proteins**

| Age level | Recommended daily amount of protein |
|---|---|
| 0 - 1 year infants | 2.0 - 2.2 g per kg of body weight |
| 1 - 20 years | 1.0 – 1.8 g per kg of body weight |
| 20 years or above | 1.8 g per kg of body weight (125 g/day for adult having 65-70 kg weight) |
| During pregnancy, lactation and recovery from illness | To be higher than the normal recommendation |

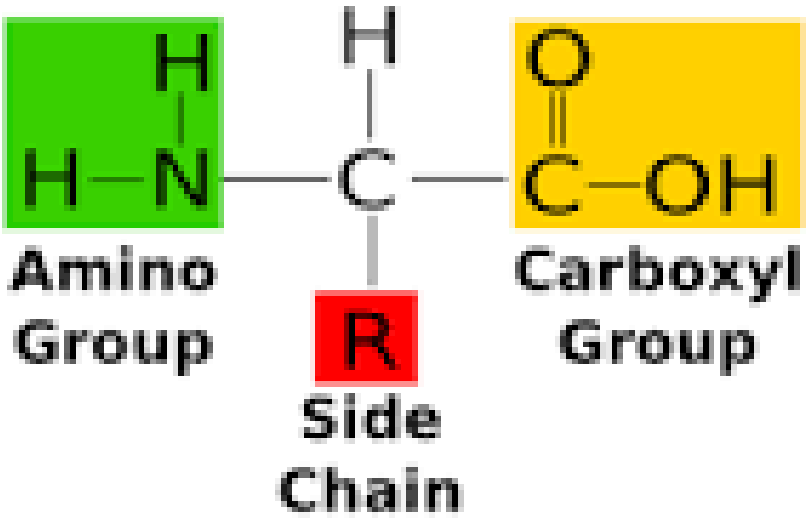
# Dietary Sources of Proteins

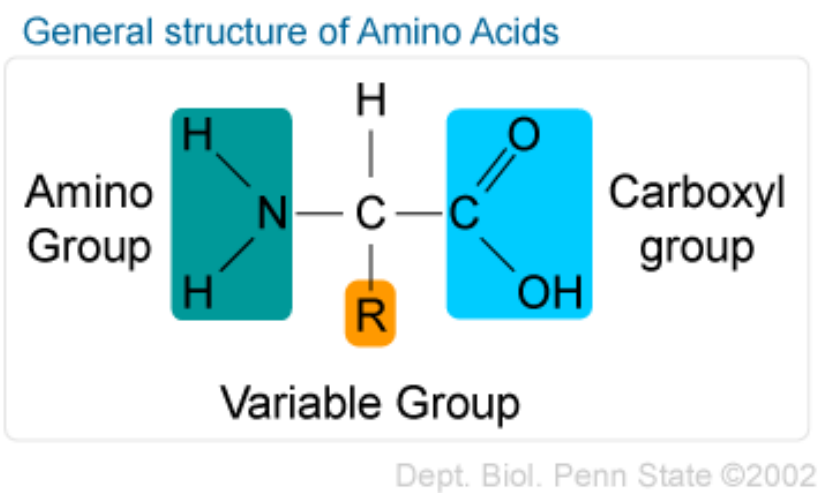
- The proportion of different amino acids required by the human infant correspond closely to the amino acid composition of human milk and hence it is accepted as the standard against which nutritional value of other foodstuffs is judged.
- Animal foods such as egg, milk and meat including fish do not differ significantly from human milk with respect to amino acid composition.
- Plant protein do not satisfy the requirement of humans. Wheat protein has a low lysine content and is only about half as effective as human milk as a source of protein.
- Legumes seeds contain between 18% and 22% protein, but are deficient in essential sulphur containing amino acids (methionine). Because of the higher protein content (about 40%) and absence of toxic compounds, soybean seeds find extensive use as a dietary source of protein.

# Amino Acid

- **Amino Acids:** Amino acids are a group of organic compounds containing two functional groups:
- amino (-$NH_2$) group and
- carboxyl (-COOH) group
- The amino group is a basic while the carboxyl group is acidic in nature. The amino acids mostly exist in ionized form in the biological system.
- Amino acids (except glycine) possess four distinct groups (R, H, $COO^-$, $NH_3^+$) held by α-carbon. α-carbon is the carbon that contains both carboxyl and amino groups and such amino acid is termed as α-amino acid.
- There are about 300 amino acids found in nature, All amino acid of human body are (L-α) amino acid as $–HN_2$ group exists side by side.

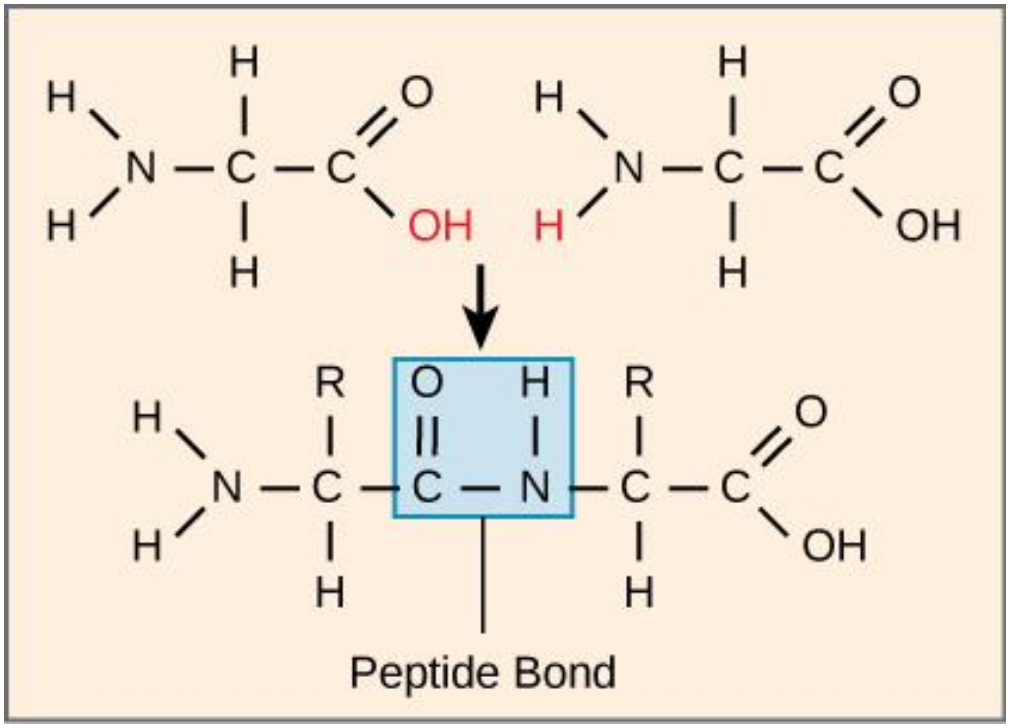
# Structure of Amino Acid




R may be any groups. If R = $CH_3$, then it is called Alanine

# Peptide Bond

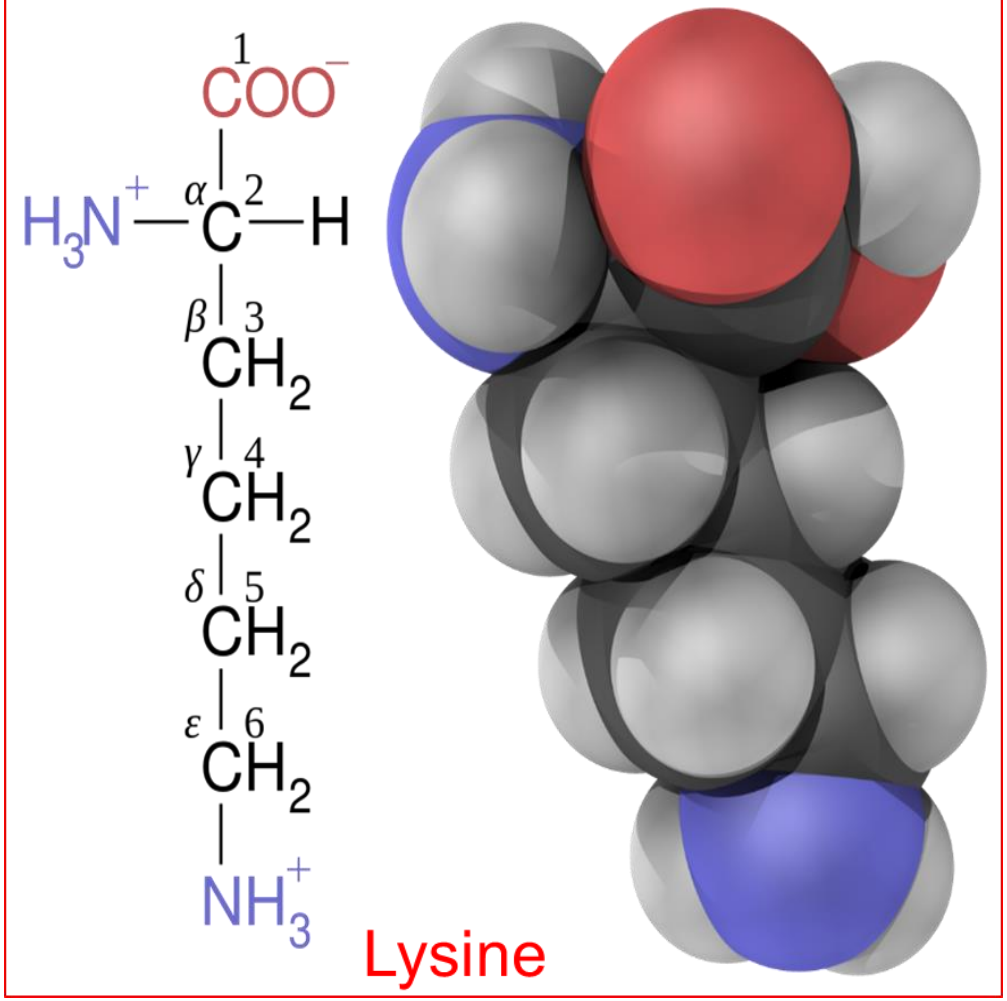



Amino acids are linked together by peptide bond. Peptide bond is made between carboxylic group (-COOH) and amino group ($-NH_2$) of two amino acids placed side by side as shown above. During peptide bonding they produce $H_2O$.

# Amino Acid (Lysine) With Carbon Atoms Labeled

- Amino acid (except glycine) possess four distinct groups (R, H, $COO^-$, $NH_3^+$) held by α-carbon.

  α-carbon is the carbon that contains both carboxyl and amino groups and such amino acid is termed as α-amino acid.



# Classification of Amino Acids

**Amino Acids can be classified as:**

A. Based on structure of side chain (R) and their reaction in solution;

B. Based on polarity of side chain (R);

C. Nutritional classification of amino acid;

D. Metabolic classification of amino acid;

# Classification of Amino Acids

**C. Nutritional classification of amino acid: Three types.**

1. ***Essential amino acid:*** Amino acids which are not produced in body and must be supplied in diets are called essential amino acids. Their presence in diet is essential. So, they are called essential.

- Essential amino acids are derived mainly from animal protein (meat, fish, egg, milk) and partly from plant proteins (pulses). Example of essential amino acids are:

  1. Met (methionine), 2. Trp (tryptophan), 3. Thr (threonine),
  4. Val (Valine), 5. Phe (phenyl alanine), 6. Ile (isoleucine),
  7. Leu (leucine), 8. Lys (lysine).

# Classification of Amino Acids

***2. Semi essential amino acid (conditional essential amino acid):*** These are produced in body, but in a limited rate, because of which they can not meet up the body demand when their requirement is high (e.g. during growth in infants and children, recovery from illness), but they can meet up the body demand when their requirement is less (e.g. in adult when there is no growth). So these amino acids must be in diet for infants and children which is not a must in case of adults. Therefore they are essential for infants and children, but not essential for adult. So, they are called semi essential amino acid. e.g. Arg (arginine), His (histidine).

# Classification of Amino Acids

1. **Non-essential amino acid:** These are produced in body in adequate amount, so their presence in diet is not essential. So, they are non-essential amino acids. For example:

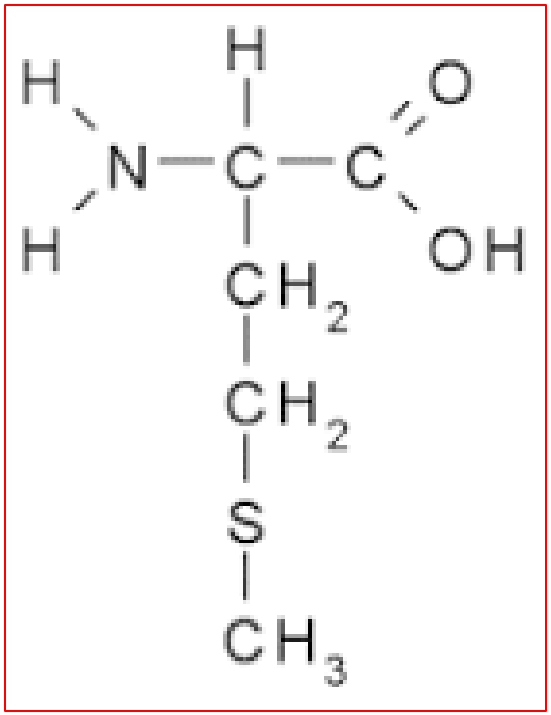
   1. Asp (aspartic acid), 2. Glu (glutamic acid),

   3. Cys (cysteine), 4. Ser (serine), 5. Gly (glycine),

   6. Ala (alanine), 7. Asn (asparagine), 8. Gln (glutamine),

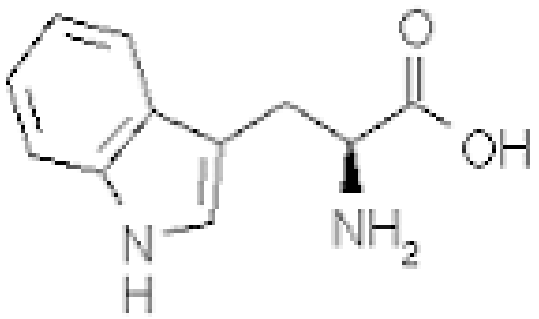
   9. Tyr (tyrosine), 10. Pro (proline).

# EAA- Methionine




**Methionine**: Methionine is a sulphur containing essential amino acid involved in the creation of cartilage and may also help prevent hair loss and strengthen nails. A deficiency of methionine can lead to inflammation of the liver (steatohepatitis), anemia, and greying hair. However, a diet low in methionine may also extend lifespan and reduce risk of cancer. High methionine foods include nuts, beef, lamb, cheese, turkey, pork, fish, shellfish, soy, eggs, dairy, and beans.

# EAA- Tryptophan




trp w Tryptophan

**Tryptophan:** Tryptophan is an essential amino acid needed for general growth and development, producing niacin, and creating serotonin in the body. Serotonin is thought to produce healthy sleep and a stable mood which is why tryptophan in turkey is sometimes attributed to making people sleepy.

High tryptophan foods include nuts, seeds, tofu, cheese, red meat, chicken, turkey, fish, oats, beans, lentils, and eggs. The recommended daily intake for tryptophan is 4 mg per kilogram of body weight or 1.8 mg per pound. So a person weighing 70kg should consume around 280mg of tryptophan per day.

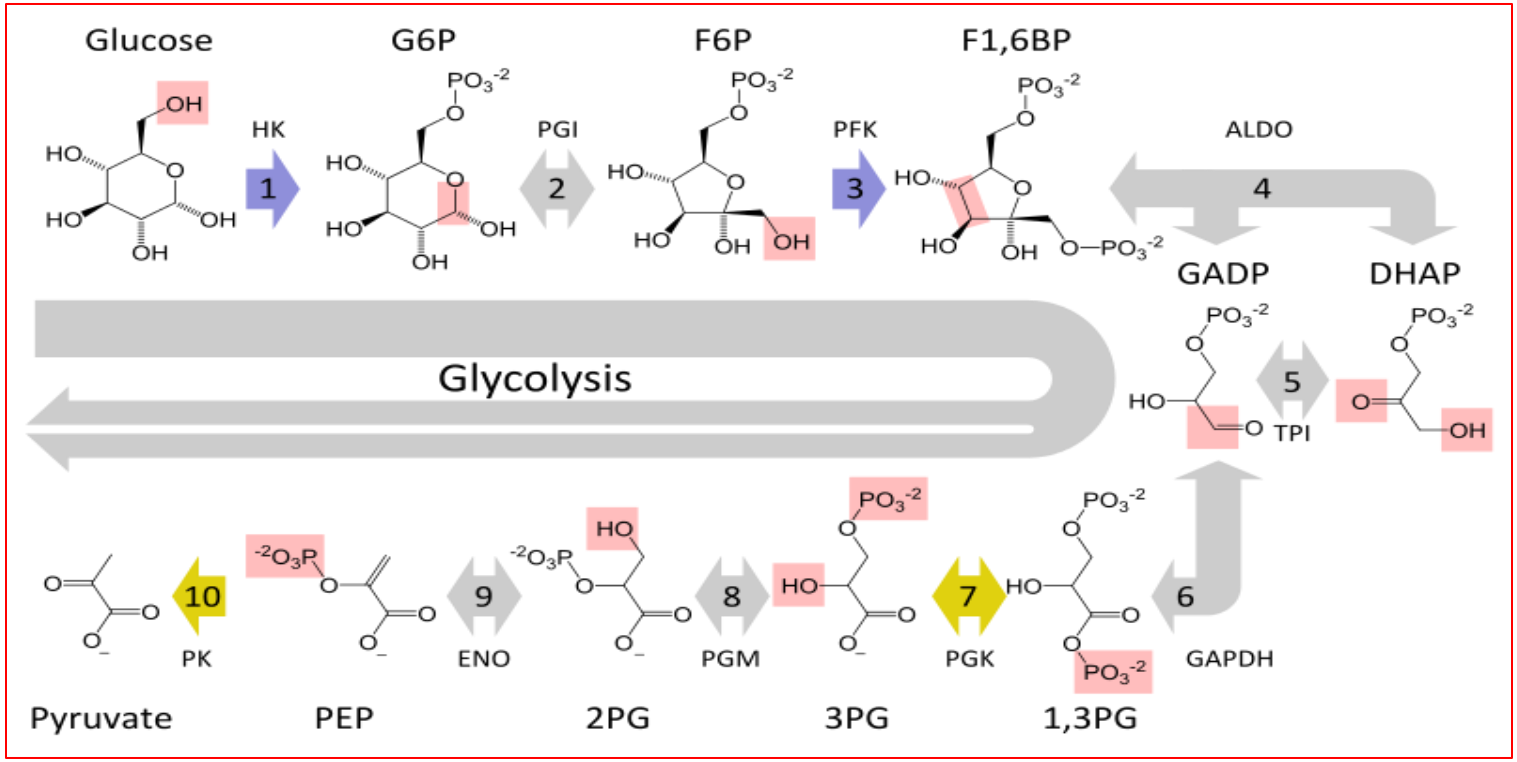
# Enzyme

- Def: Enzyme are complex globular proteins and function as catalysts in the biological systems.
- The catalytic efficiency of enzymes is very high with turn over number of several thousand.
- Unlike synthetic catalysts enzymes show a high substrate specificity as well as product specificity, function at low temperatures (even at subzero temp.) and at atmospheric pressure.
- 1.Temperature greater than 70-100$^{o}$C, 2. extreme of pH and 3. the presence of denaturing agents destroy the catalytic activity of enzymes.

# Endogenous Enzymes in Food

- Over 100 enzymes are found in the endoplasmic reticulum and ribosomes of cells. Some of the enzymes are involved in post harvest ripening of fruits.
- Cytochromes and lipoproteins of this organelle possibly catalyze lipid oxidation giving rise to off-flavors in foods.
- The endogenous enzymes of foods are of importance in processing and preservation because they cause changes in color, texture, flavor and nutritive value of foods.
- Milk contains at 20 enzymes distributed in the soluble phase, the micellar phase and the fate globules.
- Egg white contains about 12 enzymes and egg yolk about 7 enzimes.
- Wheat kernel contains about 55 enzymes in it.

# Glycolysis is a determined sequence of ten enzyme-catalyzed reactions.




**Glycolysis** (from *glycose*, an older term for glucose + *-lysis* degradation) is the metabolic pathway that converts glucose $C_6H_{12}O_6$, into pyruvate, $CH_3COCOO^- + H^+$. The free energy released in this process is used to form the high-energy molecules ATP (adenosine triphosphate).

# Endogenous Enzymes and their Activities

1. Phenolase: Phenolase is enzyme catalyzed browning in plant tissues responsible for changes in the colour and flavour of fruits and vegetables. Exposure of the cut surface of fruits such as apples, bananas and potatoes to air, particularly during unit operations of cutting, slicing, dicing or peeling result in rapid browning due to the enzymic oxidation of phenols to orthoquinones which undergo polymerization to yield brown pigments called melanins.

Phenolase activity in fruits and vegetables is undesirable while it is desirable in coffee, tea, cocoa and dried fruits. Phenolase activity is suppressed either by blanching or by addition of sulphur dioxide or sulphites, or citric, malic or phosphoric acids to lower the $P^H$ to about 3.

Thanks