Enzim

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Enzim

- Enzim, dihasilkan oleh sistem hidup, merupakan protein yg memiliki sifat katalitik.
- Sebagai katalis, enzim efisien dan sangat spesifik terkait keterlibatanya dalam reaksi kimia.
- Cofactors terlibat dalam reaksi dimana molekul dioksidasi, reduksi, dipecah ataupun digabung.

Biotechnology

- Teknik yang melibatkan penggunaan organisme hidup atau produknya untukmembuat atau memodifikasi produk untuk tujuan komerial.

Main Enzyme Classes

Enzyme class	Catalyzed reaction
Oxidirectadases	Oxidation-reduction reaction
Transferases	Transfer of functional group
Hydrolases	Hydrolytic reactions
Lyases	Group elimination (forming double bonds)
Isomerases	Isomerizaion reaction
Ligases	Bond formation coupled with a triphosphate cleavage

Enzymes in Biotechnology

- Enzymes in food and beverage production
  - Dairy industry
  - Beer industry
  - Wine and juice industry
  - Alcohol industry
  - Protein industry
  - Meat industry
  - Baking industry
  - Fat and Oil industry
- Enzymes as industrial catalysts
  - Starch processing industry
  - Antibiotic industry
  - Fine Chemicals industry

Enzymes in Biotechnology

- Enzymes as final products
  - Detergent industry
  - Cleaning agent industry
  - Pharmaceutical industry
  - Animal feed industry
  - Analytical applications
- Enzymes as processing aids
  - Textile industry
  - Leather industry
  - Paper and pulp industry
  - Sugar industry
  - Coffee industry

Faktor-faktor penting kenapa digunakan enzim

- kemungkinan reaksi tidak dapat dilakukan secara kimia.
- Reaksi spesifik
- Mereduksi jumlah tahapan proses yang dibutuhkan.
- Mengeliminasi kebutuhan pelarut organik dalam proses.
- Enzim dapat digunakan ulang melalui imobilisasi.
- Dapat dikombinasikan dengan proses lain.
- Enzim dapat diperbaiki melalui rekayasa genetika.

Industrial Enzyme Market

Annual Sales: $ 1.6 billion

Food and starch processing:	**45 %**
Detergents:	**34 %**
Textiles:	**11 %**
Leather:	**3 %**
Pulp and paper:	**1.2 %**

Beberapa contoh enzim mikrobial

- Protease: protease netral dari *Aspergillus* dan Alkali dari *Bacillus*
  - *Deterjen biologi: subtilisin dari Bacillus licheniformis dan B. subtilis*
  - *Penjernihan wine*
  - *Pengolahan kulit*
  - *Pembuatan keju*
  - *Pengempukan daging dsb*

Lipase

- Lipase terutama dari *Bacillus, Aspergillus, Rhizopus,* dan *Rhodotorula*
  - *Deterjen biologis*
  - *Pengolahan kulit – penghilangan lemak*
  - *Produksi senyawa flavor*
  - *Pengolahan susu dan daging*

Alfa Amilase

- Sumber: *Aspergillus* dan *Bacillus*
- *Untuk pengolahan pati menjadi sirup gula*
- *Modifikasi tepung dalam pembuatan roti*
- *Hidrolisis pati pada industri wine*
- *Detergent biologis*
- *Manufaktur tekstil*

Beta Amilase dan Amiloglukosidase

- *Bacillus polymyxa, Streptomyces, Rhizopus*
  - *Untuk produksi sirup maltosa*
  - *Industri beer: meningkatkan gula yg dapat difermentasi.*
- *Amiloglukosidase: A. niger, R. niveus*
  - Produksi sirup glukosa
  - Roti,
  - Beer, wine
  - Juice buah

Production of High Fructose Corn Syrups from Starch

Corn Starch Slurry (30-35% DS, pH 6.0-6.5, Ca^{2+} 50 ppm)

Liquefaction
Thermostable α-Amylase
Gelatinization (105°C, 5 min)
Dextrinization (95°C, 2h)

Liquefied Starch DE 10-15

Saccharification
Glucoamylase
(60°C, pH 4.0-4.5, 24-72 h)

Glucose Syrups DE 95-96

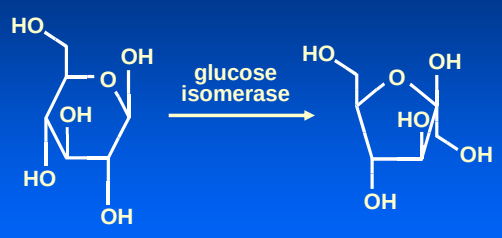
Isomerization
Glucose isomerase
(pH 7.5-8.0, 55-60°C, 5 mM Mg^{2+})

High Fructose Corn Syrups (42% fructose)

Production of Glucose from Starch

Liquefaction	Saccharification	DE	Glucose
Acid	Acid	92	85
Acid	Glucoamylase	95	91
Acid/α-amylase	Glucoamylase	96	92
α-Amylase/High pressure cooking/ α-amylase	Glucoamylase	97	93
α-Amylase (thermostable)	Glucoamylase	97	94
α-Amylase (thermostable)	Glucoamylase	97-98.5	95-97.5

Conversion of Glucose to Fructose

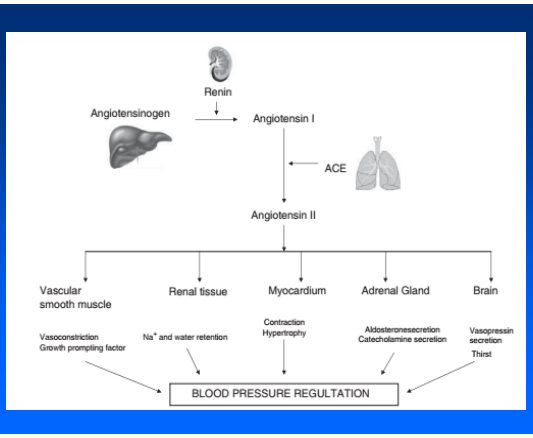


Enzim mikrobial komersial

- Enzim detergent
- Enzim dalam pengolahan Pati dan karbohidrat
- Enzim dalam produksi keju
- Enzim dalam produksi juice
- Enzim dalam Manufaktur tekstil
- Enzim dalam manufaktur kulit
- Enzim dalam penanganan pulp kayu
- Enzim untuk pencegah hipertensi

Enzim pengubah angiostensin

- EC 3.4.15.1 dipeptidyl karboksipeptidase I, kinase II.
- Enzim ini terdapat pada pembuluh kapiler paru-paru, sel endoteliel dan epitel ginjal
- Berperan dalam pengendalikan tekanan darah



Senyawa-senyawa penghambat ACE dapat diperoleh dari:

- Susu fermentasi (senyawa peptide)
- Whey susu fermentaSI
- Ikan/daging fermentasi: missal kecap ikan, sosis daging (salami, bologna, pepperoni)
- Douchii kedelai hitam terfermentsai jamur (fermentasi tradisional China)
- Natto fermnetasi kacang oleh bakteri (Jepang)
- Saus Nori (rumput laut): fermentasi rumput laut dalam kadar garam tinggi selama 2 tahun

Enzyme Kinetics Equation

$$E + S \underset{k_{-1}}{\overset{k_1}{\rightleftharpoons}} ES \underset{k_{-2}}{\overset{k_2}{\rightleftharpoons}} E + P$$

S = substrate P = product
E = enzyme
ES = enzyme-substrate complex
k_1, k_{-1}, k_2, k_{-2} are rate constants

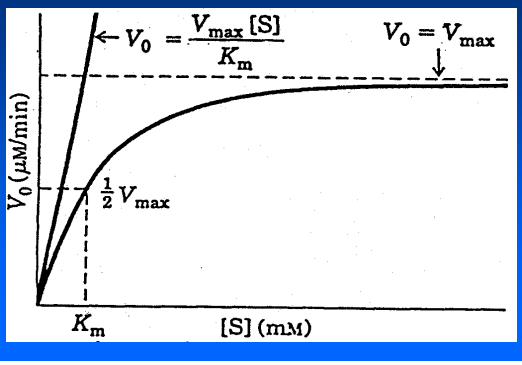
Michaelis-Menten Equation

$$v_o = \frac{[V_{max}][S]}{Km + [S]}$$

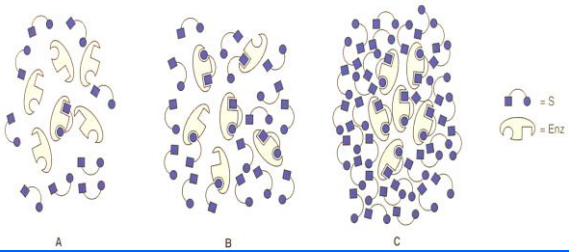
v_o = initial reaction velocity
V_{max} = maximal velocity
[S] = substrate concentration

$$K_m = \frac{k_{-1} + k_2}{k_1}$$ if $k_{-2} <<<$ (i.e., E + P back to ES is minimal)

Michaelis-Menten Curve



Substrate Saturation of an Enzyme



A. Low [S] **B. 50% [S] or K_m** **C. High, saturatir**

Lineweaver-Burk (double reciprocal plot)

- If the reciprocal (1/X) of the Michaelis-Menten equation is done, after algebraic simplification the following equation results:

$$\frac{1}{v_o} = \frac{K_m}{V_{max}} \frac{1}{[S]} + \frac{1}{V_{max}}$$

- This relation is written in the format of the equation for a straight line, y = mx + b, where $y = 1/v_o$, m (slope) = K_m/V_{max}, x = 1/[S] and the y-intercept, b = $1/V_{max}$. When this relation is plotted,the result is a straight line graph

Lineweaver-Burk (double reciprocal plot) (cont)