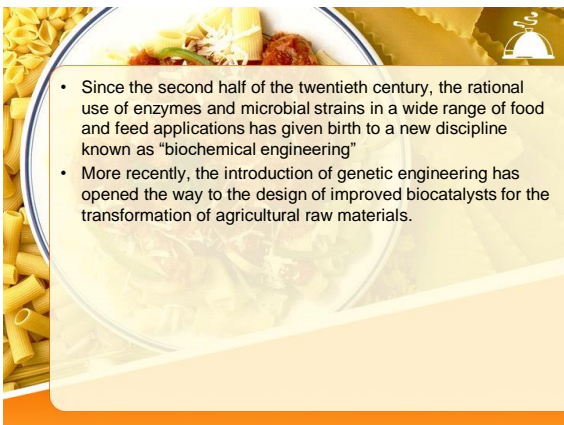


- Since the very beginning of human history, living systems and their extracts have been used on a fully empirical basis to solve one of humanity ' s most basic needs: how to produce and store food.
- Cheese and beer production are two examples of our earliest progress in this area.
- In the case of cheese, a biodegradable product, milk, is transformed into a stable, storable, and tasty derivative



- Since the second half of the twentieth century, the rational use of enzymes and microbial strains in a wide range of food and feed applications has given birth to a new discipline known as "biochemical engineering"
- More recently, the introduction of genetic engineering has opened the way to the design of improved biocatalysts for the transformation of agricultural raw materials.

Starch Transformation

Schematically, starch contains two polymers:

- amylose, which is linear, composed of α - 1,4 - osidic linkages, and generally a minor starch component (about 25 – 33%)
- amylopectin, which presents a higher degree of polymerization than amylose and which presents a similar structure but contains α - 1,6 branching linkages

Starch Transformation

- Starch is used to produce food extenders and sugars syrups such as maltodextrins, glucose, dextrose (purified glucose), fructose, maltose, and hydrogenated derivatives (e.g., sorbitol, mannitol).
- The main sources of starch are corn, potato, wheat, barley, rice, cassava, and sorghum

Starch Transformation

- The first industrial process for starch processing achieved hydrolysis using acid catalysis. The reaction was performed on starch slurry (30 – 40% dry solids) adjusted to pH 1.5 – 2.0 using hydrochloric acid. Hydrolysis was completed at 140 – 150 ° C over a 5 – 8 min period
- To start with, this enzymatic liquefaction step was achieved at pH 6.0 – 6.5 for 5 – 8 min at 85 ° C. Then, to promote starch gelatinization, the reaction mixture was heated at 140 ° C for 5 min, then cooled to 85 ° C

Dairy Industry

- Milk transformation into cheese and various processed food products is an intrinsically biological process involving enzymes and microbes.
- The lactic acid bacteria starter cultures produced by these companies are widely used.

cheese making

- animal rennet, which is a mixture of chymosin and pepsin extracted mainly from calf stomach (abomasum)
- microbial rennet, which is an extracellular proteolytic preparation obtained from fungal cultures (*Cryphonectria parasitica* , *Mucor pusillus* Lindt, *Rhizomucor miehei*)
- recombinant chymosin, which is a product of genetic engineering and is expressed by *Aspergillus niger* , *Aspergillus oryzae* , *Escherichia coli* , or *Kluyveromyces marxianus* var. *lactis*

Baking Industry

- Fungal α - amylase from *Aspergillus oryzae* is the most widely used enzyme in baking. The main effect is to reduce dough viscosity during initial starch gelatinization
- Another target for α - amylase use is the increase of shelf - life of baked products through its anti - staling effect

Beer - Making Industry

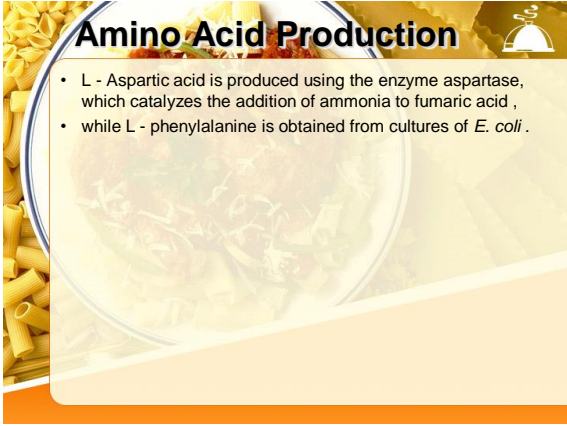
- One of the key features of brewing is the malting process, which is divided into three stages: steeping, germination, and kilning
- The aim of malting is to promote optimal hydrolysis of the cell walls in barley kernels in order to provide a quality fermentable extract upon mashing.
- Therefore, in malting as well as amylases and proteinases, endogenous glucanase and pentosan - hydrolyzing activities are essential.

Probiotics

- The human body contains about ten times more microbial cells than human ones.
- Following birth, the human gut is progressively colonized by microbial strains, starting with the mother ' s vaginal flora.
- Probiotics, mainly lactobacilli and bifidobacteria originating from the intestinal content of healthy humans, have been selected for their specific properties in extensive screening procedures.

Amino Acid Production

- Three amino acids are of interest for food applications: L - glutamic acid, L - aspartic acid, and L - phenylalanine.
- L - Glutamic acid is the most produced amino acid (1.5 million tons per year). Its manufacture, in the form of monosodium glutamate (MSG), is achieved using *Corynebacterium glutamicum* .
- Metabolic engineering of glutamate biosynthesis by *Clostridium glutamicum* has been investigated



Amino Acid Production

- L - Aspartic acid is produced using the enzyme aspartase, which catalyzes the addition of ammonia to fumaric acid ,
- while L - phenylalanine is obtained from cultures of *E. coli* .
