



Chapter 1: Food Biotechnology Timeline

Food Biotechnology Timeline

The following timeline shows the progression of food biotechnology from the earliest domestication of crops and animals to modern, efficient methods of selecting and producing plants and animals with the most desirable qualities. These dates are benchmarks of scientific and regulatory breakthroughs and highlight the important role of food biotechnology, a modern way of improving crops, food, and animals.



8500–5500 B.C. People begin to settle in one place and raise plants and animals; the best of their crop was saved to use as seed the next year.

1800 B.C. The Babylonians improve the quality of date palms by pollinating female trees with pollen from male trees with desirable characteristics.

1863 From observing pea plants in a garden, renowned scientist Mendel concludes that certain "unseen particles" (later described as genes) pass traits from parents to offspring in a predictable way—the laws of heredity begin to be understood.

1875 The first higher-yield, hardier wheat-rye hybrid grain is created.



1953 The structure of DNA is described by Watson and Crick.



1961 USDA registers *Bacillus thuringiensis* (Bt) as the first biopesticide.

1973 Scientists Cohen and Boyer successfully transfer genetic material from one organism to another.



1986 EPA approves commercial growing of the first genetically engineered crop—tobacco plants resistant to tobacco mosaic virus.

1992 FDA issues a policy stating that foods from biotech plants would be regulated in the same manner as other foods. Pre-market consultation with FDA is encouraged, consistent with industry practice.

1993 Recombinant bovine somatotropin (rbST)—a naturally occurring protein that is reproduced using biotechnology and used in cows to increase milk production—is approved in the U.S.



1994 The first whole food produced using biotechnology—the FlavrSavr® tomato—enters the marketplace after FDA issues its advisory opinion on safety. Virus-protected squash is also planted.

1998 Virus-protected papaya, developed through biotechnology to save the crop from devastation, was planted in Hawaii. Insect-protected sweet corn is also planted.



1996 Biotech varieties of soybean, cotton, corn, canola, tomato, and potato seed are planted on 4.5 million acres in Argentina, Australia, Canada, China, Mexico, and the US.



1996 Dolly the sheep is the first animal clone to be born.



1999 The Enviropig™ is genetically engineered in Canada to produce an enzyme in its saliva that would allow it to get more phosphorus from its feed. This would reduce phosphorus runoff into waterways.

2008 FDA releases its risk assessment on animal clones, concluding that food from clones is as safe as other food.



2008 Sugar beets produced with biotechnology are commercialized.



2012 Researchers report that the first "hypoallergenic" cow, Daisy, has been genetically engineered to remove a protein that can trigger whey allergy in humans.

2011 "High-oleic" soybean varieties higher in heart-healthy monounsaturated fats are available in the U.S.



2011 Additional whole foods enhanced by biotechnology are submitted for government review, including non-browning apples, and low-acrylamide potatoes.

2012 Biotech crops are planted on 420.8 million acres by 17.3 million farmers in 28 countries. More than 90% of farmers planting biotech seed are small, resource-poor farmers in developing countries.





8,000 BC

People decide to live in one place and grow plants as crops. They save the best of their crop to use as seed the next year.

4,000 BC

Egyptians master art of winemaking.

3,000 BC

South America peoples select and breed potatoes as staple crop.

2,000 BC

Egyptians and Sumerians learn brewing and cheese making.

1,800 BC

Yeast is used to make wine, beer and unleavened bread.

300 BC

Greeks develop grafting techniques for plant breeding.

1500s

Fermenting comes to the fore, leading to the development of sauerkraut and yogurt.

1784

The first brewery is established in Canada.

1861

Louis Pasteur develops pasteurization, protecting food by heating it to kill dangerous microbes, removing the air and sealing it in a container.

1865

Gregor Mendel, the father of genetics, presents his laws of heredity.

1922

Farmers first purchase hybrid seed corn created by crossbreeding two corn plants.

1940

Oswald Avery isolates pure DNA

1941

Danish microbiologist A. Justin coins term "genetic engineering".



1953

James Watson and Francis Crick describe double helix structure of DNA (receive the Nobel Prize in 1962)

1970

Norman Borlaug becomes first plant breeder to win Nobel Prize for his work on Green Revolution wheat varieties.

1973

Scientists Stanley Cohen and Herbert Boyer discover recombinant DNA technology, considered to be the birth of modern biotechnology.

1982

The first genetically engineered product, human insulin, is approved for sale in US.

1986

The agricultural industry uses biotechnology to create soybean plants that are herbicide resistant.

1988

World's first field tests for genetically engineered canola take place in Canada.

1990

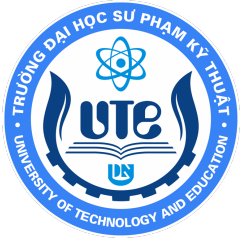
The first food products modified by biotechnology, an enzyme for cheese production and yeast for baking, are approved in US and UK respectively.

1994

The first food product enhanced through biotechnology, the FlavrSavr tomato, hits the US supermarket shelves.

1996

The commercial production of biotechnology crops begin - corn, potato and canola.



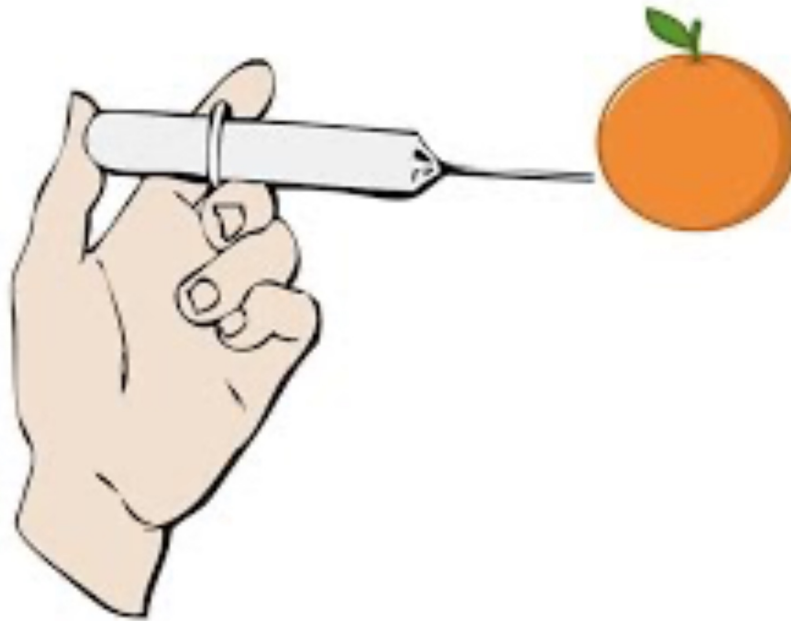
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Chapter 2: Raw materials for food biotechnology

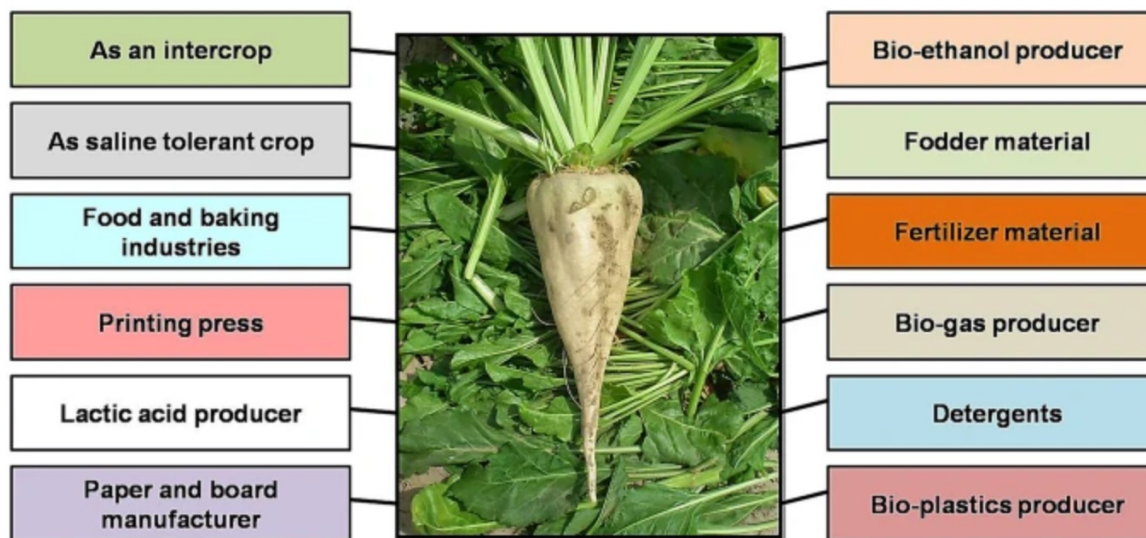
Food Biotechnology





Botanical and others classifications

Fruits and vegetables:



Milk



- Question?
 1. Milk characteristic?
 2. Milk Composition?
 3. Milk comes from?

Chapter 3: Application of microorganisms in food biotechnology

Types of micro-organisms used in food production

- ▶ Bacteria
 - ▶ Lactic acid bacteria
 - ▶ Cyanobacteria (also known as blue-green algae)
- ▶ Fungi
 - ▶ Yeasts
 - ▶ Moulds
- ▶ Algae
 - ▶ Green algae

Bacteria are classified into-cocci, or spherical cells; bacilli, or cylindrical or rod shaped cells; and spiral or curved forms. The pathogenic or disease causing bacteria are usually gram negative, however, three gram- positive rods are known to cause food intoxications : *Clostridium botulinum*, *C. perfringens*, and *Bacillus cereus*

The other most common bacteria causing **food spoilage**, infections and disease: *Acinetobacter*, *Aeromonas*, *Escherichia*, *Proteus*, *Alcaligenes*, *Flavobacterium*, *Pseudomonas*, *Arcobacter*, *Salmonella*, *Lactococcus*, *Serratia*, *Campylobacter*, *Shigella*, *Citrobacter*, *Listeria*, *Staphylococcus*, *Micrococcus*, *Corynebacterium*, *Vibrio* *Enterobacter*, *Paenibacillus*, *Weissella*, *Enterococcus*, *Yersinia*

Bacteria used in production of various food and dairy products

Streptococcus, *Lactobacillus* *Bifidobacterium*, *Erwinia* etc. are used in the production of fermented food and dairy products. *Streptococcus thermophilus* and *Lactobacillus bulgaricus* are used to produce yogurt.

Fungi:

Molds

Molds are multicellular filamentous fungi whose growth on foods is usually readily recognized by their fuzzy or cottony appearance. They are mainly responsible for food spoilage at room temperature 25-30 °C, low pH, and have minimum moisture requirement.

Molds also find their use in manufacturing of different foods and food products as cheese (e.g. Roquefort, Camembert).

Yeasts

Yeasts have the ability to ferment sugars to ethanol and carbon-dioxide and hence they are extensively in food industry. The most commonly used yeast, the baker's yeast is grown industrially.

Saccharomyces carlsbergensis is most commonly used in fermentation of most beers. The other yeast strains of importance are *Brettanomyces*, *Schizosaccharomyces*, *Candida*, *Cryptococcus*, *Debaryomyces*, *Zygosaccharomyces*, *Hanseniaspora*, *Saccharomyces*

Factors Affecting Growth of Microorganisms

- Removing or destroying them by trimming, washing, heating, pickling.
- Adding chemicals like acid or alcohol or by encouraging competition to form organisms.
- Minimizing contamination from raw or unprocessed food, people, equipment, and the environment.
- Minimizing microbial growth by cleaning and sanitizing the equipment (container etc).
- Adjusting storage pH, light penetration, temperature, and other environmental factors.

Use of micro-organisms in food production

- ▶ **Production of fermented food, e.g.**
 - ▶ Bacteria are used as the starter culture in the production of cheese and yoghurt
 - ▶ Mould is used in cheese ripening
 - ▶ Yeast is used in making bread and wine
 - ▶ Bacteria, mould and yeast are used in making soya sauce
- ▶ **Added to enhance nutritional value of food, e.g.**
 - ▶ Bacteria as probiotics
- ▶ **Used as food sources directly, e.g.**
 - ▶ Black moss is a kind of blue-green algae
 - ▶ Chlorella and seaweed are green algae
 - ▶ Mycoprotein (i.e. protein from fungi) is the common ingredient in all Quorn products

Remember:

Bacteria, molds and yeast are the most important microorganisms that cause food spoilage and also find the maximum exploitation in production of food and food products.

- Different strains of bacteria and fungus are used for fermentation of dairy products for production of a wide variety of cultured milk products. Both bacteria and fungi are used in these cheese production processes.
- Lactic acid bacteria are used for coagulation of milk that can be processed to yield a wide variety of cheeses, including soft unripened, soft ripened, semisoft, hard, and very hard types.
- Microorganisms such as *Lactobacillus* and *Bifidobacterium* are used as in food and health industry.

• *Spirulina*, a cyanobacterium, also is a popular food source sold in specialty stores.

- Molds are used for rotting of grapes for production of different varieties of wines.
- Mushrooms (*Agaricus bisporus*) are one of the most important fungi used as a food source.
- Alcoholic beverages as beer are produced by fermentation of cereals and grains using different
- strains of yeasts.

Production of fermented food

What is fermentation?

- ▶ Fermentation is a natural process in which micro-organisms turn sugar into alcohol and carbon dioxide
 - ▶ Micro-organisms used for making fermented foods are called “starters”
- ▶ **Benefits of food fermentation:**
 - ▶ Develop flavours, aromas and textures of food, e.g.
 - improvement of flavour and aromas, e.g.
 - from coffee beans to coffee, from grapes to wine
 - ▶ Extend the shelf life of food, e.g.
 - from milk to yoghurt and cheese
 - ▶ Improve the nutritional value of the product, e.g.
 - improved digestibility (e.g. from wheat to bread)
 - synthesis of probiotic compounds (e.g. from milk to yoghurt)

Ingredients	Food
Milk	Cheese Yoghurt
Meats	Sausages (e.g. Salami) Chinese ham
Grains	Yeast bread Beer and sake Chinese rice wine and rice vinegar
Plants	Szechuan pickled vegetables Pickled Chinese mustard Chinese ham
Grains	Yeast bread Beer and sake Chinese rice wine and rice vinegar
Plants	Szechuan pickled vegetables Pickled Chinese mustard Kimchi Sauerkraut Oolong tea, red tea, black tea
Legumes	Fermented bean curd, bean paste Miso, soya sauce
Fruits	Wine, vinegar
Fish and shell fish	Fermented fish, fish sauce Shrimp paste

Functions of bacteria in the production of fermented foods

- Bacteria are used to make a wide range of products
- The most important bacteria in food production is the *Lactobacillus* bacteria species, also known as lactic acid bacteria
- Lactic acid bacteria (LAB)
 - ×. LAB is a group of bacteria that can decompose lactose (a form of sugar) in milk
Lactose

Functions of moulds in the production of fermented foods

- Moulds are used to produce specific flavours and textures in several food products, e.g.
 - ×The moulds *Aspergillus oryzae* and *Aspergillus sojae* are used in the production of soya sauce and miso
 - × The mould *Penicillium* is used in the production of cheese, e.g.; Roquefort, Stilton, Gorgonzola and Danish Blue



Chapter 4: Future food biotechnology





- IMPORTANCE OF BIOTECHNOLOGY IN FOOD PROCESSING.
- ITS APPLICATIONS.
- ADVANCES IN FOOD BIOTECHNOLOGY
- RISK FACTORS
- SAFTEY REGULATIONS



Top 10 Genetically Modified Foods



Corn



Soy



Cotton



Papaya



Rice



**Rapeseed
(Canola)**



Potatoes



Tomatoes



Dairy products



Peas



- **FLAVR SAVR TOMATO**

Scientists genetically modified tomatoes to reduce the amount of enzyme polygalactouranase (breaks down pectin in cell wall) so that they may posses longer shell life.

- **GOLDEN RICE**

Rice is one of the main content in diet of most of the human population. Rice is rich in nutrients except certain vitamins like, vitamin A and E. Golden rice is a vitamin rich modified form of rice.



FOOD PACKAGING



The major goal of food packaging is the protection and preservation of the food product from environmental contamination

One of the main objective of the packaging of food is to protect it against spoilage and deterioration due to physical damage , chemical changes .



PRESERVING FOOD FLAVOUR AND QUALITY



Food often loses its flavor over time because the food flavors are often absorbed by the food packaging itself or degraded by other products within the package. This process is called flavor scalping. Foods can also pick up odors or flavors from other separately packaged foods.



High barrier materials are now being developed that prevent loss or transfer of these desirable food flavors.

RISK FACTORS

- With the increased use of developing techniques in food biotechnology, we also have increased level of risks associated with them.
- The development of techniques devised for the genetic manipulation of foods poses new risks for children with food allergy (FA).
- This allergic reaction happens when a certain protein/allergen present in the GM crop enters the body and stimulates an immune response.



SAFETY REGULATIONS

- While producing foodstuffs, packaging or simply storing finished ready-made food, specific steps in Hygiene protocol have to be taken to ensure that cross-contamination of particles, viable or non-viable, entering production zones does not occur.
- There is a need to ensure products, whether they be confectionery, nutritional or dry-foods, are made safely.

