Genetically modified foods – techniques

Genetically modified (GM) foods are created using biotechnology to change their genetic material. A variety of techniques is used. Food may be genetically modified to increase its shelf life, make it resistant to pesticides and insecticides, or improve the crop nutritional yield.

Genes are the blueprints for our bodies, governing factors such as growth and development. Within almost every cell of the body, genes are beaded along tightly bundled strands of deoxyribonucleic acid (DNA) called chromosomes, which are encased inside a special sac (nucleus).

Genes use chemical messages that instruct the cell to perform its functions by making proteins or enzymes. By introducing a foreign gene, scientists prompt the altered organism to make new proteins or enzymes, so that the cell performs new functions. For example, the gene that helps a coldwater fish survive low temperatures can be inserted into a strawberry to make it frost-resistant. The genes can be taken from an animal, plant or micro-organism. If the genes are inserted into another species, the resulting organism is referred to as transgenic.

A range of techniques
Some of the techniques used to transfer foreign cells into animals and plants include:

- Bacterial carriers
- Biolistics
- Calcium phosphate precipitation
- Electroporation
- Gene silencing
- Gene splicing
- Lipofection
- Microinjection
- Viral carriers.

Bacterial carriers
The bacterium *Agrobacterium* can infect plants, which makes it a suitable carrier for delivering DNA. The bacterium is prepared in a special solution to make its cell walls more porous. The selected gene is inserted into a bacterium extra chromosomal DNA molecule (called a plasmid) and dropped into the solution. The solution is heated, which allows the plasmid to enter the bacterium and express the new gene. The genetically altered bacterium (or recombinant) is allowed to recover (is 'rested') and grow and, depending on the plasmid, make extra copies of the new gene. The bacterium is then allowed to infect the target plant so it can deliver the plasmid and the new gene.

Biolistics
The selected DNA is attached to microscopic particles of gold or the metal tungsten. Like firing a gun, these DNA-laden particles are shot into the target cells using a burst of gas under pressure.

Calcium phosphate precipitation
The selected DNA is exposed to calcium phosphate. This mixture creates tiny granules. Target cells respond to these granules by surrounding and ingesting them (endoocytosis), allowing the granules to release the DNA and deliver it to the host nuclei and chromosome(s).

Electroporation
The prepared target cells are immersed in a special solution with the selected DNA. A short but intense electric shock is then passed through the solution. The result is small tears in the cell walls, which allow the new genetic material access to the nuclei. Then, the cells are placed into another solution and encouraged to repair their breached walls, locking the 'donor' DNA inside the cell. The selected DNA is incorporated into the host chromosomes to provide the host with a new gene.

Gene silencing

The gene responsible for the organism's undesirable trait is identified. One method of 'silencing' that particular gene is to attach a second copy of the gene the wrong way around. This technique is used to prevent plants like peanuts and wheat from producing the proteins (allergens) commonly responsible for human allergies.

Gene splicing
Bacteria contain restriction enzymes that form part of the bacterium's 'immune system' against invasion by another organism or bacteriophage (a bacterial virus). The restriction enzymes attack the foreign DNA by cutting it into precise sections and preventing it from being inserted into the bacterium's chromosome.

Different bacteria produce different restriction enzymes that cut any DNA at different places, making the DNA 'sticky' in some cases, which means they can be 'pasted' directly onto the target organism's prepared DNA.

Using these restriction enzymes from bacteria, molecular biologists can 'genetically engineer' the DNA for 'insertion' into target (host) cells to modify gene traits. The molecular biologist then uses another enzyme (ligase) to fuse the new gene into the chromosome.

Alternatively, instead of 'pasting', the new gene may be inserted into a bacterium's extra chromosomal DNA molecule (a plasmid), which carries invasion genes that allow it to invade the target cell and deliver the gene.

Lipofection
Small bubbles of fat called liposomes are used as the carriers of selected DNA. The target cells and the liposomes are placed into a special solution. The liposomes merge with the cell membrane, allowing the DNA into the cells for inclusion in the chromosome.

Microinjection
The selected DNA is injected into a fertilised ovum (female egg cell) through an extremely slender device called a glass capillary tube. The genetically modified egg is then transplanted into the prepared uterus of a receptive female and allowed to grow to term. This method ensures that almost every cell in the developing organism's body contains the new DNA but not every progeny carries the transgene (is deemed a 'transgenic' animal).

Viral carriers
A virus that will invade the target cells but not cause damage or death is chosen. The selected DNA is added to the genetic makeup of the virus, and then the virus is allowed to infect the target. As the virus invades cells and replicates, the selected DNA is added to the target cells.

Examples of genetically modified foods
Some current examples include:

- Crops are genetically engineered to be resistant to particular insect pests. For example, toxin genes (Bt toxin) from a bacterium found in soil (*Bacillus thuringiensis*) are inserted into the crop DNA so that the plants produce toxins specifically deadly to the larvae of their pest insects.
- Soybeans have been genetically modified to resist herbicides that would normally kill them.
- Plants are genetically modified to ensure longer shelf life or greater resistance to frost.
- Farm animals (such as pigs, cows and chickens) are genetically modified for faster growth rates, leaner muscle-to-fat ratios or superior resistance to disease.
- Plants are modified to yield higher protein or nutrient levels, or produce healthier oils containing 'functional food' components such as omega 3 fatty acids.
- Genetically modified cows can produce milk that contains higher levels of bioactive milk proteins or human blood clotting components or a human breast milk component.

Safety tests
In Australia, foods or ingredients that have been genetically modified (GM foods) must be subjected to a pre-market safety assessment by the government food regulator – Food Standards Australia New Zealand. Apart from certain exemptions, GM foods offered for sale must have their GM status identified on the food label.

Where to get help

- Food Standards Australia New Zealand Tel. (02) 6271 2222
- Office of the Gene Technology Regulator Tel. (02) 6271 4207 or 1800 181 030

Things to remember

- By introducing a foreign gene, scientists prompt the altered organism to make new proteins or enzymes, so that the cell performs new functions.
- Some of the many techniques used to genetically modify foods include introducing the desired DNA via benign bacterial or viral infection.
- If the genes are inserted into another species, the resulting organism is referred to as a transgenic organism.

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