

Genetically modified soybean

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Genetically modified soybean is a soybean (*Glycine max*) that has had DNA introduced into it in a way other than the combination of male and female gametes.^[1] This process may be carried out using "recombinant DNA (rDNA) technology."^[2] As a widely planted and versatile crop, soybeans have become a popular subject of genetic modification.

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Genetic modification in plants

To modify a soybean's genetic makeup, the gene to be introduced into the soybean must first be isolated. If the gene does not display an obvious phenotype, or visible characteristic, a marker gene must be linked to it so the modified cells and unmodified cells can be distinguished. According to Dr. Peter Celec, a professor in the Slovakian Comenius University's Department of Molecular Biology, the "marker genes typically confer resistance to a selective agent, often an antibiotic," so the unmodified cells can easily be killed off to leave only modified cells behind, and the "other [gene] is meant to confer a desirable phenotype, which is often agronomic (herbicide, pest, stress resistance) or related to food quality (shelf-life, taste, nutritional value)."^[3] Once the gene to be put into the soybean's DNA is isolated, there are several ways to insert the gene, though the most popular are by "biolistics," by using *Agrobacterium*, by electroporation, or by "gene knockout".

Biolistics

Biolistics, more formally known as ballistic bombardment, is a process in which atoms of a heavy metal element, such as tungsten or gold, are coated with the gene to be adopted by the plant and then fired, with gunpowder, into a sample of plant cells, as described by Professor Sibel Roller of South Bank University, London, and Susan Harlander, a vice president of Pillsbury's research and development department. These atoms penetrate the cell walls, leaving the genes free to code into the plant's DNA. As the description implies, with its very uncomplicated and explosive process, this is one of the oldest methods of genetic engineering, as it was developed in 1990.^[4]

Agrobacterium

Agrobacterium tumefaciens is a type of bacteria that transfers its DNA via horizontal gene transfer to create tumors in plants. This makes it very useful to genetic engineering. Gene transfer using it happens when "a restriction enzyme is used to cut non-virulent plasmid DNA derived from *A. tumefaciens* and thus create an insertion point, into which the gene can be ligated. The engineered plasmid is then put into a strain of *A. tumefaciens*, which contains a 'helper' plasmid and plant cells are treated with the recombinant bacterium" in culture.^[3] While this looks like a complicated concept, it is really only a genetic engineering version of cut and paste.

Electroporation

Electroporation is exactly what its namesake implies—it is the creation of pores by using electricity. Specifically, it is when a pulsed magnetic field is used to create pores in plant cells, “through which genes can be taken up, and in the form of naked DNA incorporated into the plant genome.”^[3]

Gene knockout

Gene knockout, also known as antisense technology or gene neutralization, is used when a gene in a plant is undesirable or inhibits the function of the new gene that will be introduced. To “knock out” this gene, a noncoding strand of DNA (DNA that does not translate into any genes) is used to silence the undesirable trait.^[5]

Examples of transgenic soybeans

The genetic makeup of a soybean gives it a wide variety of uses, thus keeping it in high demand. First, manufacturers only wanted to use transgenics to be able to grow more soy at a minimal cost to meet this demand, and to fix any problems in the growing process, but they eventually found they could modify the soybean to contain healthier components, or even focus on one aspect of the soybean to produce in larger quantities. These phases became known as the first and second generation of genetically modified (GM) foods. As Dr. Celec describes, “benefits of the first generation of GM foods were oriented towards the production process and companies, the second generation of GM foods offers, on contrary, various advantages and added value for the consumer,” including “improved nutritional composition or even therapeutic effects.”^[2]

Roundup Ready Soybean

Main article: Roundup Ready soybean

The Roundup Ready soybean, also known as soybean GTS 40-3-2, is a transgenic soybean that has been immunized to the Roundup herbicide. Since the soybean’s natural trypsin inhibitors provide protection against pests, the only major problem in soy farming was weeds,^[6] thus making soybean 40-3-2 revolutionary. According to Dr. Gerhardt Wenzel, a professor at the Technische Universität in Munich, Germany and a deputy member of the “Zentrale Kommission für die Biologische Sicherheit” (ZKBS), the glyphosate in the herbicide would inhibit the soybean plant’s ESPSP gene, which is involved in the maintenance of the “biosynthesis of aromatic metabolites,” and cause the plant to die along with the weeds for which the herbicide was meant.^[7] A plasmid which was transferred to the soybean cells through the cauliflower mosaic virus^[citation needed] was soon developed to provide immunity to glyphosate-containing herbicides, and, after this process was perfected, the Roundup Ready soybean was ready, first hitting the US market in 1996.^[8]

Bt Soybean

Monsanto developed a soybean expressing Cry1Ac protein from *Bacillus thuringiensis* and the glyphosate-resistance gene, which completed the Brazilian regulatory process in 2010.^{[9][10][11]}

Transgenic soybean oil

According to Dr. Wenzel, the “soybean is the crop with the best amino acid composition within all cultivated protein crops.”^[8] Since amino acids are directly used in the genetic formation of proteins and fatty acids, this makes the soybean invaluable in oil production. The food industry wanted both an increase in soy oil per soybean and an alteration in the types of oils the soybean produced. Tom E. Clemente, from the University of Nebraska’s Department of Biochemistry, describes the unmodified soybean as follows:

Commodity soybean oil is composed of five fatty acids: palmitic acid (16:0), stearic acid (18:0), oleic acid (18:1), linoleic acid (18:2), and linolenic acid (18:3). The percentage of these five fatty acids in soybean oil averages 10%, 4%, 18%, 55%, and 13%, respectively. This fatty acid profile results in low oxidative stability that limits the uses of soybean oil in food products and industrial applications. Oxidative breakdown of soybean oil, for example, results in rancidity and off flavors in food products.^[12]

The main goals in genetic modification of the soybean were thus to improve oxidative stability by changing the mass percentage of certain fatty acids, which would provide a more useful oil, and to increase the overall amount of oil produced.

Increasing oxidative stability

The main fatty acids that would need to be increased to achieve oxidative stability (without creating *trans* or polyunsaturated fatty acids) were oleic acid and stearic acid, and the main fatty acid to be decreased was linolenic acid.^[13] To accomplish this, genetic engineers and food scientists, according to Anthony J. Kinney and Susan Knowlton of DuPont Agricultural Products, there were two keys: First, silencing, or knocking out, the delta 12 desaturase gene; and second, preventing the formation of the plant's delta 9 desaturase enzyme.^[14] Doing this increases levels of oleic and stearic acid in soybeans. This combination of fatty acids creates an oil that is ideal for the food industry, because it creates a healthier oil that can be used for frying products, nut roasting, and carrying food colors or flavors.^[15] DuPont has actually announced the creation of a high oleic fatty acid soybean, with levels of oleic acid greater than 80%, to be released into the market in 2010.^[16]

Increasing amount of oil produced

Even a small change in the amount of oil a soybean produces could affect industry profits marginally, so manufacturers are motivated to create soybeans that produce a greater amount of oil. However, the protein produced by soybeans is also in high demand, so the main problem scientists and companies faced was creating higher oil content without disrupting protein content. According to Clemente, "the only transgenic success reported to date for enhancement of soybean oil content was achieved by the introduction of a seed-specific transgene for a DGAT2-type enzyme from the oil-accumulating fungus *Umbelopsis ramanniana*. In these studies, the oil content was increased from approximately 20% of the seed weight to approximately 21.5%."^[17] Though 1.5% does not sound like much, but given the size of the soybean industry, that small increase causes millions of dollars more in sales.

Transgenic vs. conventional soybeans

Transgenic soybeans are marketed all over the world, and the sale of conventional soybeans is decreasing more and more. The United States produces GM soybeans (the Roundup Ready variety) almost entirely, at 85%, and often conventional soybeans are mixed with the GM variety, as no distinction is made between the two.^[18] However, genetic modification is deemed by some groups as unethical or immoral, while others are quite enthused at the opportunities it provides. Genetic modification in plants is really only an extension of applied plants genetics, the process of interbreeding different plants to get desired traits. However, genetic engineering allows the desired trait to be specifically selected and inserted into the plant, making it much less random, and with genetic engineering, it is also possible to cross species barriers.^[21] While there are many modifications that "improve" the soybean, there are also some unintended effects. Ping-Jian Deng, et al., from the Shenzhen Center for Disease Control and Prevention in China, found that in glyphosate-resistant soybeans, stems were splitting and up to 40% yield reduction was occurring at high soil temperatures (at 45°C), and there was more lignin (20%) at normal temperatures (20°C).^[19] The main fear of the public, however, is that consumption of genetically modified DNA will affect their health in adverse ways. José Domingo, from the Laboratory of Toxicology and Environmental Health at "Rovira I Virgili" University, Spain, explains, after extensive testing, that DNA consumption of GMOs is essentially the same as DNA consumption of non-GMOs, and any risk of gene transfer in GMOs is extremely unlikely.^[20] According to Harry A. Kuiper, et al., from the National Institute for Quality Control of Agricultural Products, all genetically modified plants put onto the food market are thoroughly^[citation needed] tested and reviewed by the Food and Drug Administration (FDA) in the United States, as well as by the Food and Agriculture Organization (FAO) of the United Nations, the World Health Organization (WHO), and many other health and regulatory organizations. If they are found substantially equivalent to their unmodified counterparts, or, if they are too different from their counterpart, are found safe to consume, causing no negative effects on health, the transgenic products are approved.^[21] Therefore, any GMO currently on the market has been considered safe for consumption in the United States.

Notes

- [^] Roller, 5
- [^] *a b c* Celec, 531
- [^] *a b c* Celec, 533
- [^] Roller, 6
- [^] Celec 533
- [^] "Molecular Pharming"
- [^] Wenzel, 57
- [^] *a b* Wenzel, 55
- [^] Monsanto's Bt Roundup Ready 2 Yield Soybeans Approved for Planting in Brazil - Crop Biotech Update (8/27/2010) | ISAAA.org/KC (<http://www.isaaa.org/kc/cropbiotechupdate/article/default.asp?ID=6565>)
- [^] Staff, Monsanto. August, 2009. Application for authorization to place on the market MON 87701 × MON 89788 soybean in the European Union, according to Regulation (EC) No 1829/2003 on genetically modified food and feed (http://www.gmo-compass.org/pdf/regulation/soybean/MON87701xMON89788_soybean_application_food_feed.pdf) Linked from the GMO Compass page on the MON87701 x MON89788 (<http://www.gmo-compass.org/eng/gmo/db/147.docu.html>) event.
- [^] Monsanto's Bt Roundup Ready 2 Yield Soybeans Approved for Planting in Brazil - Crop Biotech Update (8/27/2010) | ISAAA.org/KC (<http://www.isaaa.org/kc/cropbiotechupdate/article/default.asp?ID=6565>)
- [^] Clemente, 1030

- 13. ^ Clemente, 1031
- 14. ^ Anthony, 196-7
- 15. ^ Clemente, 1032
- 16. ^ Clemente, 1038
- 17. ^ Clemente, 1037

- 18. ^ "Genetically Modified Soybean"
- 19. ^ Deng, 2406
- 20. ^ Domingo, 727-30
- 21. ^ Kuiper, 504

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See also

- GTS 40-3-2
- Vistive Gold

External links

- GMO Safety: USA: 'Superweeds' encouraged by genetically modified plants? (<http://www.gmo-safety.eu/news/653.usa-superweeds-encouraged-plants.html>)

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