Genetically Modified Tomatoes

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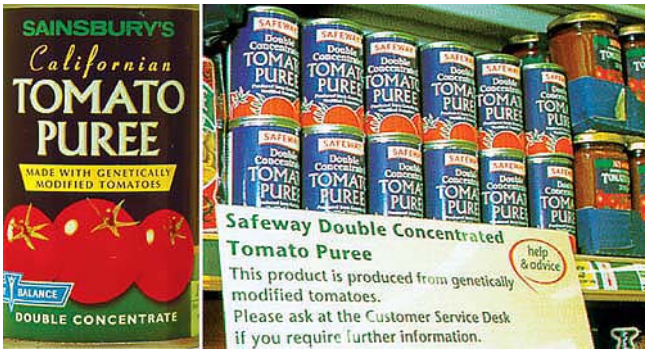
Preface

When we were first told we had to write a semester work on genetic engineering we were rather ignorant about this topic. But when we discussed it, we realized that genetics is in many ways huge nowadays: both as a fast developing science, as a project for solving humanity's food problems, and as an innovative new way of mankind interfering with or improving nature. We first researched on the Internet and found various interesting sub-topics. Particularly the genetically modified (GM) tomatoes drew our attention as we all love Italian food, tomato sauce and insalata caprese. The idea of creating tomatoes with a full flavor that keep longer than "normal" tomatoes is fascinating. So we read up on GM tomatoes. Our findings showed that GM tomatoes are not commercially cultivated and sold, or rather that they were sold on the U.S. and UK markets in the 90s and then with-drawn. This made us wonder: why weren't they sold anymore? And what happened to the "FlavrSavr" tomato that was commercially distributed in the U.S.? On YouTube, we chanced upon an advert for the "FlavrSavr" tomato, which promised the customer that this new brand would have great taste, amazing quality and freshness and in addition cost less than regular tomatoes. So why was the "FlavrSavr" tomato taken from the market? It interested us to find out about the positive and negative issues of genetically manipulated tomatoes. Will they make production easier or just cheaper? Will the quality of the fruit be better? Or is it just commercial interests? Is the claim of the genetic engineering industry that they are working on saving global food problems justified? Moreover, are there any health risks in consuming GM food?
Not all of these questions will be answered in our paper, because not all are answerable at the moment. But it's worth taking a closer look.

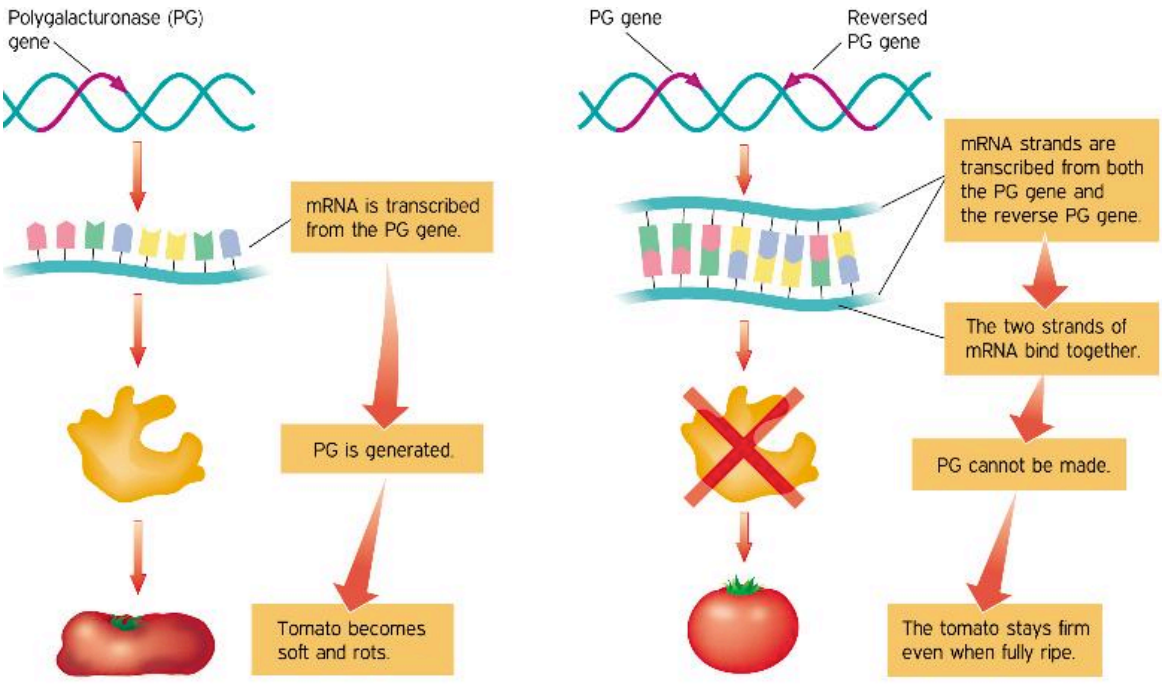
Introduction

In the last years, a couple of companies were trying to find a way to manipulate the genes of tomatoes – either to get a better flavour, to lengthen their storage time or just to make further processing easier. But only two of these attempts were successful, and these tomatoes passed all the tests and were sold in the stores. The first of these was the "Flavr-Savr" tomato in the United States. It is special because it was the first genetically engineered food that was granted a license for human consumption. The company Calgene manipulated the genes of the tomato so the ripe fruits wouldn't get soft and mushy that fast. In this way the tomatoes could ripen on the stems all the way and didn't have to be harvested too early. This is an important point because normally tomatoes are harvested while still green to prevent any damage during the transportation and to make sure the consumer can at least keep them for a couple of days.
In this perspective, the "FlavrSavr" tomato brought an important improvement in tomato harvesting: the fruit could reach its full natural flavour and colour and still enjoy a long shelf-life. The first "FlavrSavr" tomatoes were sold in the U.S. in 1994. But they didn't sell too well because they didn't taste as good as promised and customers held back. The reason for their lack of flavour (in spite of the name!) was that the tomato species chosen for genetic engineering did not have a lot of flavour in the first place and moreover was susceptible to diseases. But this only came out after all the work had been done. So the development of the "FlavrSavr" tomato didn't bring Calgene the success the company had hoped for and the production was stopped in 1997.
In the UK, a company called Zeneca also tried to produce genetically modified tomatoes. As their GM tomatoes were a lot cheaper to produce and process, the company through this found a way to lower the price of tomato paste considerably. In 1996 Zeneca started selling tomato paste that was almost 20% cheaper than the regular brands. They had to mention on the label that the tomatoes were modified (see picture) but the consumers didn't care and made it a huge success. Only when in 1998 activists started campaigning against GM food did the sales figures drop and Zeneca stopped the production in 1999.
Since then, there haven't been any genetically modified tomatoes or products with modified tomatoes in the stores in Europe and the U.S.



Description of engineering technique

It is important to distinguish plant cells from animal cells, because they exhibit very different characteristics. For example, plant cells have a cell wall and a large central vacuole.
Requirements for a gene to be manipulated are natural proteins that cut a DNA strand, for example a gene in an exactly defined position.
If such proteins are in operation, the new genetic information to be inserted into the plants must be isolated from the donor organism. In the case of the "FlavrSavr" tomato this was a single tomato gene, which was inserted in reversed orientation so that the genetic reading of the gene directing the ripening of the fruit would be blocked (see graphic below). In other cases the transferred gene may originate from different plants. For instance, the widely cultivated insect-resistant so-called Bt plants contain a gene of the soil bacterium *Bacillus thuringiensis*.
In a second step, the gene to be transferred is inserted into the individual plant cell and is built into the nucleus. In this process, a second marker gene is frequently added. The latter serves to identify the cells that have taken in DNA. Finally, through specific growing conditions, this single plant cell that has incorporated new genetic material is grown into an integral plant that carries the new genetic information in each of its cells.
Geneticists have developed alternatives to this procedure. One of these is a gene cannon, which "shoots" tiny little metal balls directly into the plant cells. The plant cells repair the "injuries" quickly and engineer the newly received DNA into their chromosomes.
In both methods the success rate is rarely over 1:10'000 per cell. It isn't possible to determine where the new gene (or perhaps multiple copies of it) is attached.



Documentation and pictures of research institutions visited

Before our work was finished we did an interview with Jan Lucht, a researcher in genetic engineering. The transcribed interview ran about three pages, so we had to shorten it. It was not possible to take photos of a work place. Below are the questions we found the most interesting:

- *What are the risks when consuming genetically modified tomatoes (or genetically modified vegetables in general)?*

There is no reason to suppose that there are other risks than with "normal" vegetables, e.g. the risks of bacterial infection if the vegetables are insufficiently washed. These risks are completely independent from any genetic engineering – an example would be the European EHEC-epidemic of 2011 when almost 3000 people were infected and over 50 died from consuming organically produced sprouts. Meanwhile, GMPs (genetically modified plants) like corn, rape and soy have been produced for 17 years in increasing bulks and serve as food every day and several million times for humans and animals. Up to now there has not been a single documented case for either humans or farm animals that can be traced back to its genetic modification.
Moreover, there is no plausible scientific explanation why GMPs should be a health risk, as every GMP is put through extensive security tests before its approval as foodstuff. This is the reason why GMPs have the reputation of being the food the most profoundly tested and thereby the safest around. For instance: if some new, exotic fruit is imported and sold here, the import dealer must provide hardly any special tests. If it indeed would bring about dangerous allergies (as it happened with kiwis), nobody will be particularly bothered, as any fruit is perceived as "natural". Whereas if any GMP-fruit ever caused allergies, it would probably be perceived in different ways … this has never happened and seems improbable – due to the thorough examinations before market approval of GMPs.

- *What does the future look like? Is there a chance that in Switzerland at some point GM tomatoes will be put on the market and sold successfully?*

I'm persuaded that we will see GMPs in Switzerland at some point in the future. In principle they are approved even today (or some, like GM corn and GM soy, see Swiss Federal Office for Health), but retailers don't take them up because they think that nobody wants to buy GM products. This is not altogether correct, there were experiments selling bread containing GMO corn or conventional corn, and 23.7% of the customers bought at least one loaf of GM corn bread. In fact the consumers welcomed the chance to have a free choice of GM and conventional products. On the other hand, it can't be denied that most consumers feel very sceptical and mistrust GM products and that at the moment only a small minority would be willing to purchase them. Also in my opinion the reason for the retailers' reticence towards

GMPs lies in their fear of being targeted by protest groups like the WWF or Greenpeace. The protests are always organised to great public effect and the retailers are afraid of the back-lash – widespread fall in reputation, "there's no smoke without fire", consumer mistrust, etc. On the side of agricultural production, it becomes ever clearer that GMPs would contribute in very important ways to agricultural sustainability also in Switzerland (see Swiss Academy of Sciences) and that their negative public image seems to be unjustified. For example, GM potatoes need less spraying against fungus diseases – instead of spraying them 8 to 12 times per year like now they would only need 3 to 4 sprayings. This would mean not only less work for the farmer but also less environmental stress. The U.S. agriculture seems much more open for these economic arguments, as are the U.S. consumers, e.g. towards an oil made from GM soy that's said to be as healthy as olive oil.
In general, an argument in favour of GM products is that the consumer should have the freedom of choice.

- *Are there other means of increasing the shelf life of vegetables?*

In the case of the "FlavrSavr" tomato the purpose of the genetic modification was not to increase its storage span but to leave the fruit longer at the stem and increase its flavour. But then the "FlavrSavr" tomatoes turned out to be "harder" and could be stored for longer periods than regular tomatoes. This initiated further development of GM tomatoes with longer storage spans – but nowhere are these GM vegetables as yet on the market! Because although these vegetables don't get mushy and stay usable for a long time, it is not yet clear whether the nutrients are staying unchanged or not.
This is why at the moment, rather than applying GM methods, it seems more promising to improve traditional storage methods, e.g. it is now possible to keep apples fresh for eight months in so-called CA-storage (CA = Controlled Atmosphere).

- *What is your personal opinion as to GM food?*

I myself have worked for years in basic research with GMPs, have eaten bread and polenta made with GM corn, and I have no anxieties whatsoever about health issues. I regret that in Switzerland (and in other European countries) I can't buy GM products whereas in other parts of the globe they are entirely accepted. Of course I can accept that the question of genetic engineering finds many different answers, positive and negative ones, but in the end each individual has to decide for himself what to eat.
It's a pity that so many critics of genetic engineering are so intolerant and narrow-minded. I would prefer discussions that are not based on ideology but more on scientific arguments. And I would like to see the point of sustainable production given more attention. It is never useful to judge simply in black or white, totally for or totally against – there is more often a golden mean.

Discussion

What progress was made with the genetic modification of tomatoes?

When the first GM tomatoes came on the market, they were a huge success for the industry and the managers excitedly saw a golden future for marketing. Never before had it been possible to keep tomatoes fresh for such a long time and never before had tomato paste been so cheap. The producers hoped to increase their profit because GM tomatoes were growing faster, transportation was easier and further processing was less expensive. Many researchers and marketing people were convinced that these tomatoes were the first step towards a wider selection of GM foods and also were paving the way towards solving the problem of hunger and insufficient nutrition.
But these GM tomatoes were not as successful as predicted. Apart from the fact that their taste was rather average, the public started questioning the technique of genetic engineering and worried about various health issues. These concentrated on the uncertainty whether GM food caused any long-term health risks. The GM tomatoes contain a gene, which has a blueprint for an enzyme that is resistant to the antibiotic *Kanamycin*. If the entrobacteria of a person consuming a GM tomato absorbed such a gene, built it into their genome and constructed such a resistant protein, the antibiotic would not work in case of an infection. Other points of discussion touched on ethnical and biological matters, for instance that the modification of genes is an intervention into natural processes and that the ecological balance could be in danger of being disturbed. We'll discuss these considerations in more detail below.

What future research steps are on the horizon?

The field of genetic engineering is really vast and it is hard to get an overview. So many researchers are working on so many different projects in science and applied science, and understandably the companies keep their findings very much under wraps. They fear the criticism of opponents from the outside, but most of all competition and spying from other interested parties. After all, successful genetic engineering has the potential of big money. Actually, GM tomatoes are still a topic of research (because of their wide use as processed food) and we can't be sure that there won't be future attempts to market another brand of GM tomato – perhaps with more success because by now the public is getting used to GM food in the shops, though most often in "hidden" forms as basic ingredients, like soy or corn. Indeed, with soy GM brands are more than half of the total global production.

Advantages of genetically modified tomato production – the "FlavrSavr" tomato

- Since prehistoric times, when mankind settled down as hunter-gatherers and farmers, animals and plants have been cultivated selectively (see grain like wheat or barley; see domestic animals). Wild plants were purposely chosen for traits like yield,

resilience to the cold or the wet, or the quality of its fruit. This choice was carried out – before genetic engineering entered the picture – by planned cross-fertilization.

- Whereas with traditional methods it takes ten to fifteen years before a new type or variant of a plant is ready for cultivation, the techniques of genetic transfer can shorten this period considerably, often to the half. Moreover, a selective genetic transfer enables quicker, less messy cross-fertilization, because the properties of the plant that are going to be transferred are decided on beforehand.
- The "FlavrSavr" tomato was thoroughly examined and controlled in order to avoid any risks when putting it on the market. The producers were afraid of damages claims and aware of the consumers' scepticism towards GMPs. In contrast, with traditionally produced tomatoes there are hardly any of these security tests, even if some of the risks are theoretically the same (allergies, residues of chemical substances).
- The added gene of the "FlavrSavr" tomato does not form a new protein and thus a new, "unnatural" tomato plant. On the contrary: It keeps the protein that is responsible for fast spoiling from multiplying.

Disadvantages or ethical arguments against genetic engineering

- If a new gene is introduced in a plant the DNA at the place where this procedure took place may undergo changes, so-called position effects. This means that a neighbouring tomato-gene may be changing and so produce less or more of its specific gene and thus influence the balance, mass and or concentration of specific plant ingredients. In theory these changes could also affect the so-called Alkaloids, and the Tomatin of the tomato plant is an Alkaloid that is poisonous in higher concentration. On the other hand, these position effects are not limited to GMPs but exist also with traditionally produced plants.
- GMPs may be scientifically inventive and risk-free, but there is a big problem on the side of economic interests. Because research is very costly international food and seed conglomerates like Kraft Foods or Monsanto or Nestle have mostly taken it up. They want to make profit and target markets that need help with their food production, which is often rapidly growing developing nations. So the promise of alleviating hunger and malnutrition pays off very well for these companies.
- Plus they have huge sums of money at their disposal for unlimited advertising and promotion campaigns.
- The last argument contra GMPs concerns the ultimate question of man's manipulating the workings of Nature by trial and error – not always to the best effect.

Summary

The “FlavrSavr” tomato was the first GM fruit that was marketed in the 90s in the U.S. and the UK, but with mixed success. The story of the “FlavrSavr” tomato enabled us to present some arguments for and against genetically modified products: from the basics of genetic engineering to questions of health and how to market a GM product. The industrial history of the “FlavrSavr” tomato up to now is a mixture of scientific results (the genetic modification: harder skin) with economic purposes (how to market the fruit: longer storage time, emphasise the added flavour) and emotional reservations on the consumer’s side. This mixture of pros and cons is typical for GM products. If the genetic manipulation is “hidden” in a processed product (like with GM soy or corn in chocolate bars, or with the tomato paste containing GM tomatoes), it is accepted as “part of the food parcel” by the consumers. One could say: If they don’t see it, they don’t mind.

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Pictures

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