tion was detected in 71% of products labeled "non-GM", "GMO free" and/or "organic". In the USA, the FDA (Food and Drug Administration) suggests that "free" refers to low minimal levels, but not in fact "GM free". Different countries have different threshold levels of GM levels which are acceptable before a product can be called non-GM, e.g. EU has a threshold of 0.9%, Australia and New Zealand have a threshold of 1.0%.

Some groups feel that if all GM foods are not labeled, consumers lose their right to choose between GM products and non-GM products. They would like the South African government to require mandatory labeling of all GM food, including labeling animal products derived from animals fed with GM feed. The government explains that compulsory labeling would be expensive and could possibly raise the price of food by an average of 10%. Because maize is a staple of so many people in South Africa, this potential price increase is politically difficult.

In addition, the informal market for fresh produce in South Africa is very large, and regulating this sector would be extremely difficult. In certain food products there is no DNA (such as sugar), and thus detecting whether or not such products are in fact from GM crops may be problematic. Also, it may be difficult to segregate GM crops from non-GM crops going into food production. These explanations can be found online **http://www.doh.gov.za/department/foodcontrol/docs/explain.html.**

GMOs in medicine

GMOs can be applied in numerous aspects of medicine. GMOs are already being used to produce insulin, growth hormones and various antibodies used in cancer treatments. Other potential future applications include "gene therapy". All techniques for this application are still under research and in trial phases and are not yet being used in clinics. Examples include treatments for diabetes, cystic fibrosis, cancer and HIV.

Vaccine developments are using GM techniques to insert specific genes from disease-causing viruses and/or bacteria , into harmless viruses. These inserts potentially allow the body to develop immunity to the original, infectious virus or bacterium. In this way, we can develop an immune response in a way which is harmless to the body. Current HIV and TB GMO vaccines are being tested in trials in South Africa.

The process known as **"pharming"** refers to using GM animals and plants to produce particular proteins as medicines. Such production techniques could dramatically reduce the cost of producing medicines. The gene for the desired protein, such as ones for vaccines, antibodies or other therapeutic proteins, is inserted into the animal or plant. For example, sheep and pigs can be modified to produce insulin, interferon and human blood clotting protein factor-8 in their milk. Research is also going into producing crops to produce vaccines. The CSIR is involved research to transform maize to carry antibodies to HIV. UCT has a plant-based vaccines research group working on Human Papillomavirus (HPV) and HIV plant-based vaccine. Despite the potential in this field, there are concerns of safety and contamination of food supplies, and production of such medicines may in future be limited to non-food crops.

The PUB programme is an initiative of the Department of Science and Technology and is implemented by SAASTA. The mandate of PUB is to promote a clear, balanced understanding of the potential of biotechnology and to ensure broad public awareness, dialogue and debate about biotechnology and its current and potential applications.
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PROMOTING A CLEAR, BALANCED UNDERSTANDING OF BIOTECHNOLOGY

PUBLIC UNDERSTANDING OF BIOTECHNOLOGY

GENETICALLY MODIFIED ORGANISMS **(GMOs)**

What is a GMO?

A genetically modified organism (GMO) is an organism (plant, animal, bacteria or virus) whose genetic makeup has been modified for a particular purpose. The organism does not occur naturally in this modified state. For example, a plant can be modified to carry an additional gene found in another living thing (such as a bacteria) to protect itself against insect pests.

Genes carry the information or the "recipe", in the sequences and structures of DNA, which gives the organism its specific characteristics. Genes can be added, removed or changed, using modern biotechnology methods. Because genes are common to life on earth, genes can be transferred from one organism to another and even between non-related species. This manipulation can produce a product with new characteristics which may have advantages.

How are GMOs useful to us?

Food: GM (genetically modified) plants are already being cultivated as crops and consumed by humans and animals. Using genetic engineering, new improved varieties of crops can be produced more quickly than with conventional breeding methods. Crops can be modified to have valuable characteristics such as tolerance to drought and herbicides, resistance to disease and insects, as well as improved nutritional content.

Medicine:

- Insulin as a treatment for diabetes was the first commercial healthcare product produced by GMOs. Bacteria were genetically modified to have a copy of the human insulin gene, and the protein is synthesized by the bacteria.
- GMOs can produce other medicines such as growth hormone.
- GMOs are used in current vaccines such as Hepatitis B (produced by yeast), and new vaccines are being developed using GMO technology. In the future, plants may even be engineered to contain the vaccines so that we may be able to eat our vaccinations rather go for an injection.
- In the future, GMOs may be used for gene therapy to correct certain genetic conditions.

Textiles: GM cotton has been created to be resistant to insect attack to improve the yield of the crop.

GM crops and food

As the world population continues to grow and more people need food, it becomes necessary to increase food production. This can either be though the clearing of new land for agriculture, or by increasing yield of the crops on the same amount or less land. The first generation of GMO technology has been directed at reducing the risks of various threats to crop yields such as insect attack and virus infection. Scientists have been adding genes to crop plants to give benefits to farmers. Four GM crops are cultivated in South Africa: insect-resistant cotton (since 1997), insect-resistant maize (since 1998), herbicide-tolerant cotton (since 2000) and herbicide-tolerant soybeans (since 2001). (Herbicides are chemical products used to destroy weeds, but not the crop plants.)

In 2004, it was estimated that GM crops accounted for 24% of yellow maize, 10% of white maize, 50% of soybean and 85% of cotton in South Africa. South Africa now ranks eighth of GM crop producing countries. Latest statistics from 2007 indicate that 51% of yellow maize, 62% of white maize, 80% of soybean and 90% of cotton produced were GM crops.

NRF National Research Foundation
SAASTA South African Agency for Science and Technology Advancement

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Measurements of GM content in food products published in 2006 showed that 90% of soy products and 60% of maize products tested in South Africa contained GMOs.

How are the new varieties created?

Insect resistance: The bacterium *Bacillus thuringiensis* (Bt) is toxic to certain insects. Scientists incorporate the gene from this bacterium that makes it toxic to insects, into the plant. The production of this toxin in the plant protects it against the insect attack. The GM plant becomes known as, for example, Bt cotton or Bt maize.

Herbicide (weed killer) tolerance: A gene from a bacterium is introduced into the plant to make it less sensitive to harmful effects of herbicides. In this way, herbicides can be used on crops to kill weeds and invasive plants while not affecting the crops.

Virus resistance: Genes from a virus which causes disease are incorporated into the plant. These genes allow the plant to become resistant to the disease.

The specific GM technology used in South African GM crops were all developed overseas. Now South African scientists are researching and developing GM crops to solve problems specific to Africa, such as crops resistant to drought, maize resistant to virus infection and crops with improved nutritional content. For example, they are transferring genes from the indigenous 'resurrection' plant *Xerophyta viscose*, which is naturally drought tolerant, to crops which are affected by drought. Maize resistant to a virus called maize streak virus (a disease with a major economic and social impact in sub-Saharan Africa), is also being developed.

Second generation GM crops are aimed at improving the nutritional properties of the crops to enhance human health. There is strong evidence that deficiencies in iron, zinc and vitamins are a major cause of underlying health problems in many developing countries. In these countries much of the diet is from starchy, staple foods such as rice, wheat and maize. Biofortification is the name given to the process of enriching the nutrient content of plants as they grow. One of the first biofortified crops produced by genetic engineering was rice grains containing beta-carotene, known as "golden rice".

Another example is carrots which are being engineered to have a higher calcium content. It has been shown that the calcium content of these biofortified carrots can be better absorbed and used by the body. This is an important aspect of improving nutritional content of plants. Increased nutrients must be readily absorbed and available to the body. South Africa is also involved in the Africa Biofortified Sorghum (ABS) project to enrich sorghum with essential amino acids and vitamins.

As with all new technologies, there are both potential benefits and risks/limitations indicated by the scientific research undertaken to date.

Benefits

- Environmental benefits: Farmers can use less pesticide on insect-resistant GM plants. This means fewer chemicals that can damage the environment are washed into the soil.
- Health benefits: Farmers need to use less pesticide on insect resistant plants, which results in healthier food.
- GM crops are better protected by, and are not so susceptible to diseases, insects and herbicides, allowing a more consistent yield.
- Pest resistant GM crops reduces the need to 'blanket' spray an entire crop, which impacts the entire insect population. GM pest resistant crops effectively target only pest insects that eat the crop.
- Higher yields of crops due to improved protection (it should be noted that in ideal conditions, i.e. no pests or weeds, GM crops have no superior yield compared to their conventional counterparts).
- It costs less to produce crops due to lower susceptibility to viruses and insects. The crops have greater "hardiness".
- Costs are potentially saved through a reduced need for pesticides and/or herbicides.
- GM crops can allow 'no-tillage' farming, which has benefits both for the farmer and for the environment.

Risks/Limitations

- Environmental risks: Farmers may use weed killers indiscriminately on herbicide resistant crops if they know their crops are less susceptible to these chemicals.
- The toxic effects of insect resistant plants could potentially also kill beneficial insects such as bees.
- Although the BT toxins are specific only to certain classes of insects, the longer term impacts on the ecosystem is not yet well established.
- Insect resistant or herbicide tolerant crops can potentially cause the development of harmful pest resistance plants, or so-called "superweeds".

- Can small-scale farmers benefit from GM crops?
  - The cost of GM seeds includes a 'technology fee', with the result that small-scale farmers may not be able to afford it. Farmers using GM seeds have to pay a technology fee to the supplier.
  - Some traits such as herbicide resistance may be of no benefit to small scale or subsistence farmers if they cannot afford to buy herbicides
  - GM crops are patented, and farmers may not retain seed for breeding purposes.
  - Although the safety of GM products is tested in intense, short term studies, the long-term effects on health of GM food consumption is not established.

Safety and concerns of GM crops

The cultivation of GM crops is controversial, mainly because of concerns around the long-term effect on human health and on the environment.

GM food has to undergo stringent tests for safety. GM foods are the only foods subjected to such strict testing. The University of the Free State's Genetically Modified Organisms testing facility is researching the health effects of GM crops.

There are three main concerns regarding the safety of GM crops:

- "Outcrossing", or the movement of genes from the GM crops to conventional crops or wild relatives. This can be managed by clearly separating the fields of GM and conventional crops.
- Although the potential is almost vanishingly small, and not specific to GM foods, genes associated with the GMO can potentially be transferred to the body or to the bacteria that exist naturally in the gut. This can potentially create superbugs.
- The potential of new allergens through the transfer of genes from foreign organisms. Allergens are compounds that cause allergic reactions. No allergic effects have been found in any GM food currently on the market. An example is where researchers became concerned when, during the development of a GM soybean crop, it was found that the soybeans caused an allergic reaction. This soybean crop was modified to contain a gene from a Brazil nut, aimed to improve the protein content of soybeans. The Brazil nut is a highly allergenic food, and it was subsequently discovered that the gene transferred caused the allergic reaction. Research on this crop was stopped.

There are systems and regulatory processes in place in South Africa which evaluate and regulate GM crops and food. Before any GM crop is released it is investigated for safety to both human health and the environment.

Who determines whether GMOs are safe?

South African regulations are determined by the South African government following standards set in the "Cartagena Protocol on Biosafety", and guidelines from the international regulatory body called Codex (Codex Alimentarius Commission). This is a joint Food and Agricultural Organisation (FAO) and World Health Organisation (WHO) body which compiles the standards, codes of practice, guidelines and recommendations which together form the international food code. The procedures for dealing with GMOs in South Africa are stipulated in the Genetically Modified Organisms Act of 1997. Applications to test, produce and trade in GM crops must be sent to the Registrar at the National Department of Agriculture.

The application is evaluated by a scientific advisory committee which consists of a number of expert scientists. The scientific advisory committee provides a recommendation to the Council to accept or reject the application, or requests further information on certain points. For field trials, the public is invited to comment on an article required to be published by the applicant in three local/national newspapers. Comments by the public are taken into consideration by the Council. The Council is represented by six government departments, and is the decision-making body regarding the application for the introduction of any GMO into South Africa.

GMO labelling

Regulations for the labeling of GM foods in South Africa are stipulated in the Foodstuffs, Cosmetics and Disinfectants Act, 1972, and are expressed in "Regulations Relating to the Labelling of Foodstuffs Obtained Through Certain Techniques of Genetic Modification" (Government Gazette No. 25908, 2004).

Labelling is currently regulated by the Department of Health.

GM foods do not need to be labelled unless:

- A GM food differs significantly in composition, nutritional value, mode of storage, preparation, or cooking from that of its corresponding foodstuff.
- The label of a GM food must indicate the likelihood of an allergic reaction if the inserted gene is derived from the major allergens: crustaceans, eggs, fish, milk, groundnuts, mollusks, soybeans, tree nuts or wheat.
- The food must be labeled if a plant food contains genetic material derived from an animal or human, or if an animal-derived food contains genetic material from a human or a different animal family.

There are no regulations regarding labeling of animals or animal products which have been fed on genetically modified feed.

Where an industry wants to label a product voluntarily to indicate enhanced characteristics due to the genetic modification, such labeling must be validated by a body accredited to SANAS (South African National Accreditation System).

The Government Gazette published "Regulations Governing the Labelling and Advertising of Foodstuffs" (No. R. 2034 Regulation 9(d)) in 1993. This prohibits any label or advertisement claiming that a foodstuff is free from a particular substance if all other foodstuffs in the same class are free from that substance. In other words, a product cannot be labeled "GM-free" if no GM products are available in that class of food as this would be misleading and imply that any products not labeled "GM-free" would be genetically modified.

It is important to note that a label stating that a product is not GM may not necessarily be truly free of the GMO product. In the study by Viljoen *et al* (2006), it was found that genetic modifica-