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Food Labeling for Use of Genetically Engineered Crops



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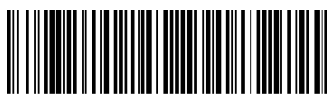
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ABSTRACT

Many genetically modified foods are currently being developed, and various products that use them are available on the market. However, few consumers understand exactly what genetic modification is. Additionally, the safety of foods produced using this technology has not been well clarified. In this paper, we first describe how the genetic modification of crops is carried out. We then provide an overview of the advantages and disadvantages of genetically modified foods. Finally, we introduce food labeling in Japan and discuss how consumers should handle it.



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INTRODUCTION

Many crops that are eaten every day, such as rice, vegetables, and fruits, have been developed in various different ways over the years. Varieties that are highly convenient for humans (e.g., crops that are resistant to pests and can grow in cold regions) are currently on the market. In the natural world, many living things have undergone gradual changes in their properties during the process of evolution to protect themselves from climate change and adversaries. It is possible that only those organisms that were able to adapt to the environment survived. With regard to crops, breed improvement has been carried out to promote the ease of growing the plants and the deliciousness of the harvested ingredients^{1),2)}.

To this end, the method used by humans, in the beginning, was the so-called act of crossing plants. The pollen used is not of the same species but of closely related species, and its properties (such as high sugar content and fruit size) are replaced over a long period of time at the genetic level. As is well known, the basic method of transmitting genetic information to offspring follows Mendel's laws. Offspring inherit genes from the paternal (pollen side) and the maternal (plant body side with pistils) strains. The properties of the offspring (next-generation plants and crops to be harvested) change depending on the probability of entry of each parent gene. Depending on the gene type, there are those that tend to be transmitted dominantly (dominant inheritance) or only recessively (recessive inheritance). In particular, traits that are transmitted recessively can be changed such that all offspring have the same trait as a result of many generations of mating¹⁾. However, this process is very time-consuming, because it takes several months to a year for the plant to grow and the seeds to be harvested (one generation change). Additionally, such crossing can only be performed using closely related species.

In recent years, many genetically modified foods have been developed; their processed products are already on the market in several countries, including Japan. This genetic modification technology is very different from conventional pollination methods. In this paper, we provide an overview of genetic modification technology, mainly referring to the labeling of food products in Japan, and present our opinion on this matter.

What is genetic modification of crops?

Genetic modification of crops is a technology that can help extract genes with useful properties from other organisms and artificially incorporate them into plants²⁾. When a gene (DNA) from one organism is incorporated into another, it can be expected to provide genetic information for making proteins in the new organism, and that the resulting proteins will fulfill their functions. Genetic modification forms the basis of modern biotechnology. Using this method, it is possible to extract genes from any organism, cut, and splice DNA in a test tube using various enzymes, and integrate DNA from one organism into another³⁾. This technology makes it possible to use the genes of organisms that cannot be crossed in the natural world (extreme examples are animals and microorganisms); thus, it is possible to create crops (plants) with characteristics that were thought to be impossible with conventional breeding through cross-pollination²⁾.

For example, pesticide-resistance genes have been incorporated to produce herbicide-tolerant soybeans. As a result, not only is it easier to remove weeds but it also eliminates the need to dig up the soil, preventing it from being blown away by the wind and thus lost²⁾. Labor for weeding can be significantly reduced and costs can be minimized. Pest-resistant corn can also be used to control pests without the use of pesticides, leading to higher yields. It is produced by introducing genes from other plants or microorganisms that produce substances that are toxic only to pests. This causes pests that consume the crop to die. If this property is provided, the amount of insecticide used can be reduced, leading to a reduction in drug purchasing costs.

Genetic modification technology not only expands the scope of crop improvement but also shortens the improvement period²⁾. Because Japan relies on global imports for much of its food demand, many foods distributed domestically contain genetically modified crops grown overseas. Currently, Japan allows imports of only eight genetically modified crops: corn, rapeseed, soybeans, cottonseed, potato, sugar beet, alfalfa, and papaya. Among these, the four most commonly distributed are corn, rapeseed, soybean, and cottonseed⁴⁾. In addition to agricultural crops, the range of applications is expanding to include ornamental plants; the ability to change the color of flowers and the shape of plants can enrich lives. In Japan, the cultivation of genetically modified crops is not specifically prohibited; however, commercial cultivation (in large quantities) has not been carried out to date. This is thought to be because the country is

satisfied with imported crops. However, experimental cultivation (in small quantities) by universities and companies is being carried out.

Differences between gene-modified and genome-edited foods

Cells that make up the body contain genes, which act as blueprints to determine how the individual (the body as a whole) changes. Genetic modification is a technology that changes characteristics by supplementing or replacing such blueprints (genes) with the blueprint information of other organisms. Genome editing is a technology that intentionally expresses characteristics different from the original blueprint by replacing, removing, or amplifying a part of the blueprint that originally existed⁵⁾. Thus, there is a difference between adding genes from the outside and only editing the original genes. Genome editing is the act of modifying the original gene to enhance, attenuate, or eliminate its action. Similar to genome editing, changes in the original gene information due to external stimuli (for example, radiation-induced single-base substitutions in DNA) can also occur in the natural world. Organisms with new characteristics are known to arise through mutations. The fact that biodiversity has developed over a long period can also be attributed to this. In 2020, tomatoes became the first genome-edited food approved in Japan⁵⁾. These tomatoes contain a large amount of γ -aminobutyric acid, which is expected to have antihypertensive and stress-relieving effects. There are also potatoes that do not produce toxins in their buds, and sea bream that exhibit increased muscle mass.

Advantages and disadvantages of genetically modified foods

The advantages and disadvantages of genetically modified foods have been stated^{6),7)}. The merits are **A)** the possibility of solving food problems and **B)** the possibility of developing foods that are less likely to cause allergies. The demerits that have been pointed out are problems such as **C)** the possibility of adverse health effects, **D)** environmental impact, and **E)** control of agriculture (seeds) by large corporations.

A) The world population continues to grow and is expected to reach approximately 10 billion by 2050, 30 years from now⁷⁾. Hence, there is a high possibility that there will be food shortages worldwide, and it is expected that there will be shortages in fuel and livestock feed. Global warming, which is one of the problems of the global environment, is expected to progress;

therefore, it will be difficult to grow crops as before, and it will naturally be difficult to increase yields more than ever. Existing resources cannot cope with the ever-growing population. The use of genetically engineered crops may help solve this problem. If a gene that is resistant to cold damage is introduced, crops can be grown even in regions with cold climates, thus increasing the total field area.

B) A food allergy is an excessive reaction of the human body to specific substances in crops, resulting in pathological symptoms. Owing to this, there are a few people who cannot eat certain crops. To solve this problem, crops can be genetically modified so that they do not produce allergenic substances. Although not yet put into practical use, the day may come when such crops will be distributed in the near future.

C) Experiments using mice have shown that the continued consumption of genetically modified crops can cause malignant tumors and visceral disorders, as well as increased neonatal mortality^{4),6)}. Consequently, the average life expectancy is also significantly shortened. These results may not apply to humans because of the species difference and the fact that we are using high-concentration substances only for short periods of time. However, research in Argentina has shown that even in humans, miscarriages, stillbirths, infertility, birth defects, and cancers have increased rapidly in the last few years^{4),6)}. This effect is thought to be caused by the application of herbicides during the cultivation of genetically modified crops; however, the details are not well understood. It was thought that only the target genes are affected in genetically modified foods; to the contrary, it has now been confirmed that other genes are also affected⁴⁾. In addition, there is the implication of the danger of feed ingested by livestock (life support of livestock, the safety of meat after livestock are slaughtered)⁵⁾.

D) Genetically modified foods can adversely affect both humans and the environment. Contamination of soil and water with chemicals has become a problem because pests and weeds that are resistant to pesticides and herbicides have increased and it has become necessary to use more effective drugs. Genetic modification has made it possible to prevent crops from withering; nevertheless, it can be said that this problem was caused by the free use of pesticides⁴⁾. An extension of this issue is to consider its impact on biodiversity. There is a risk that organisms

created via genetic modification will hinder the growth of other species or cause the extinction of native species⁵⁾.

Currently, there are strict regulations for each variety of genetically modified crop in Japan. With regard to food safety in Japan (related to **C** above), there are the Food Safety Basic Act and Food Sanitation Act. In addition, the impact of genetically modified crops on wild animals and plants in Japan (related to **D**) is scientifically evaluated based on the Cartagena Act. Only products with confirmed safety are imported, distributed, and consumed⁸⁾. Labeling rules have been established based on food labeling standards for genetically modified crops and processed foods that have been confirmed to be safe (described later). In other words, only products that have been scientifically evaluated in some way and confirmed to be safe and have no environmental impact are on the market.

Food labeling in Japan

The law stipulates that genetically modified crops and their processed products distributed in Japan should be labeled. As shown in Table 1, some have mandatory labeling, whereas, for others, it is optional⁸⁾. In principle, only foods for which the kind of genetic modification is known and those that can be verified by testing are on the market. Items for which there is no clarity on genetic modification are not supposed to be distributed in the market. Labeling is obligatory if the product contains genetically modified crops. This is likely due to the difference in market value between genetically modified and non-genetically modified foods, and consumer perception that their safety has not yet been fully confirmed (Figs. 1 and 2). Testing is difficult if the food is not solid (for example, a liquid such as oil or soy sauce), and if nucleic acid cannot be extracted from it; therefore, labeling is not obligatory. If it is known whether or not genetically modified crops are used as raw materials, it is permissible to voluntarily label them and provide information to consumers. If it is still unclear, it must be labeled as “indiscretion” (possibly mixed).

Until March 2023, such a display method was acceptable in Japan; however, from April 2023, some display methods have been changed. Under the previous rule, crops that were unintentionally contaminated with genetically modified crops at levels of 5% or less could be arbitrarily labeled as not genetically modified (those containing a small amount were ignored)⁸⁾.

For such a small level of contamination, the new description is “Classification production distribution management finished.” It should be noted that if a product is not genetically modified, it is not obligatory to label it. This is thought to be because many consumers are concerned about whether or not products contain genetically modified components, even in small amounts. This is because even if the content is small, there is a perception that some kind of toxicity will occur if a large amount is consumed. Some processed foods are also subject to labeling obligations. This includes tofu (including soybeans) and snack foods (including potatoes and corn).

What hinders genetic modification?

Genetically modified foods may cause public concern^{1),9)}. It is not surprising that the deliberate labeling of non-genetically modified products gives consumers the impression that genetically modified foods are bad (or of inferior quality) (Fig. 2). However, before discussing the safety of genetic modification, it may be necessary to consider whether it is ethically and religiously acceptable and to discuss the pros and cons of genetically modified crops based on the understanding of all people in the society³⁾. Depending on the type of disposition that changes as a result of genetic modification, it may be perceived as a blasphemy against God or the arrogance of man. This indicates that not only do certain people not eat modified food for religious reasons, but there is also the danger of such people attacking, through speech and violence, those around them who consume the modified food. Hence, there is a possibility of developing problems in human relations.

To date, many studies have been conducted on plant-derived foodstuffs to improve breeds through genetic modification. These are already on the market, whereas others are being studied. However, foodstuffs derived from genetically modified animals have not been studied extensively. There are several possible reasons for this, one of which is that mammals such as cows and pigs are closely related to humans, and it is considered undesirable to change their genes from a religious or ethical point of view. Another reason is that genetic modification changes genes for the convenience of humans, not for that of individual animals. It has been pointed out that animals, which are more motile than plants, escape from their breeding places, and contact and mate with wild animals, causing species disturbance in the natural world, with

the possibility of loss of wildlife diversity. At the research level, fish and mice are sometimes genetically modified in laboratories; however, they are only used for the purpose determined in a strictly controlled place. Before commencement of an experiment, it is necessary to conduct a content review and confirm that the methodology does not cause undue stress or pain to the animal models. Animals have been genetically modified to produce human proteins for medical treatments, establish models for diseases that frequently occur in humans, and elucidate gene functions.

CONCLUSION

Genetically modified crops can be mass-produced; considering the future increase in the world population, genetic modification of crops is considered to be a method that should be widely adopted. If it is not confirmed that there is clear danger in such modification, it seems that there is no choice but to use it. Considering that Japan imports large quantities of soybeans and corn, it is apparent that many genetically modified foods are in circulation even if they are not labeled⁴⁾. Genetically engineered products are not necessarily dangerous or unhealthy but are rather food that can keep us alive, at least in the short term. The results of animal experiments conducted thus far indicate so. However, there are also concerns, such as diseases in mice. It cannot be assumed that a food product does not contain genetically modified components simply because it is not labeled as such. This is because there are exceptional cases in which labeling is not required when the contaminant is present at a very low level. Since the history of genetically modified crops is short, and safety tests have only been conducted using animals other than humans, it can be assumed that we are currently being tested⁶⁾.

The use of genetically modified foods is expected to increase; however, such use must not be adopted carelessly. There is a big difference between eating after properly obtaining information about what kind of genetic modification has been done and eating without obtaining any information. It would be better to try to analyze foods in some way first.

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Table 1 Differences in labeling methods for genetically modified crops

Differences in labeling methods	Obligatory labeling	Optional labeling	Overview
Contains genetically modified crops	Labeled as “Genetically Modified”	(Not displayed)	Labeling applies to crops that can be confirmed to have been genetically modified by detecting protein or nucleic acid content.
Not included*,**	(Not displayed)	Labeled as “Not genetically modified” (until March 2023) Labeled as “Classification production distribution management finished” (from April 2023)	There is no labeling obligation for non-genetically modified crops and processed foods made from them.
Inclusion is ambiguous	Labeled as “Genetically modified indiscriminate”	There is no obligation to label but the labeling on the left is optional***	Labeling applies to foods when they contain crops that can be confirmed to have been genetically modified by detecting protein or nucleic acid content (regardless of whether it is the main ingredient).

“ ” indicates the labeling on the food.

* If unintentional contamination occurs during the production and distribution stages, labeling as “not genetically modified” is allowed if the content of genetically modified ingredients is 5% or less (until March 2023).

** There is no obligation to label cows, pigs, etc. that have eaten genetically modified crops as feed.

*** Processed foods (such as oil and soy sauce) in which modified DNA or protein cannot be detected by inspection do not need to be labeled.

Based on the contents of reference 8).

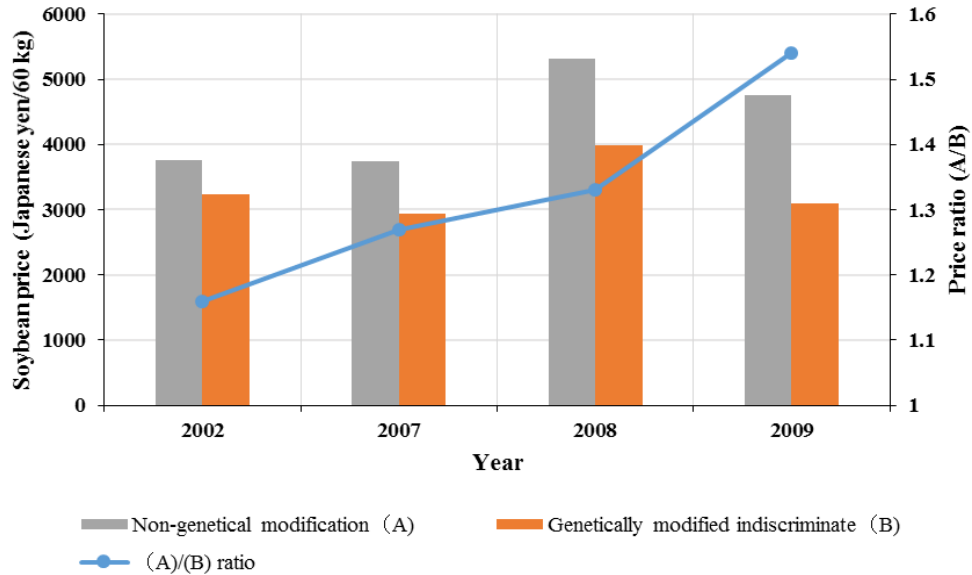
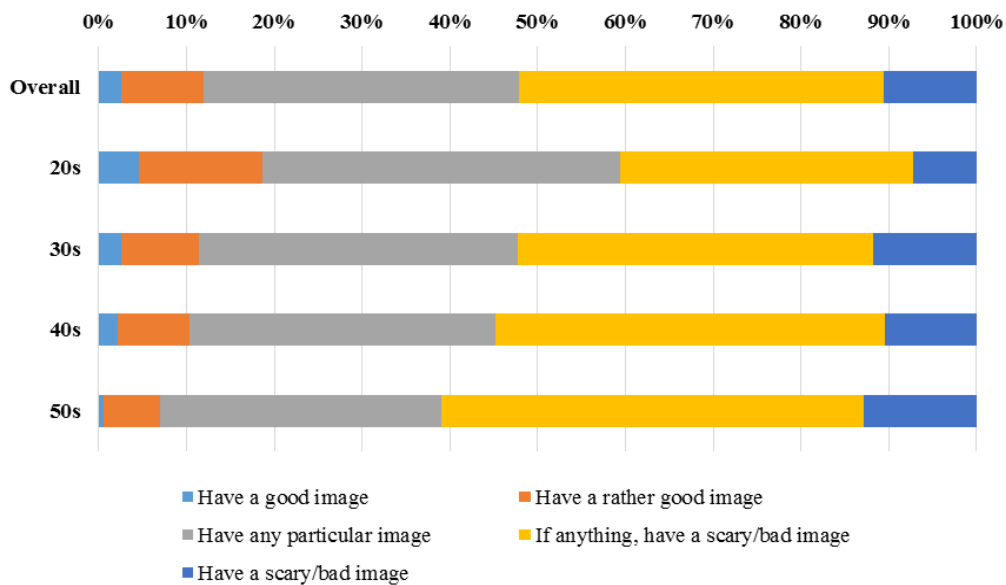


Fig. 1 Prices of soybeans imported into Japan

The price indicated is the calendar year average price in the Nikkei market.

Based on the data in reference 1).

1) What image do you have of genetically modified foods?



2) Do you think genetically modified foods are necessary?

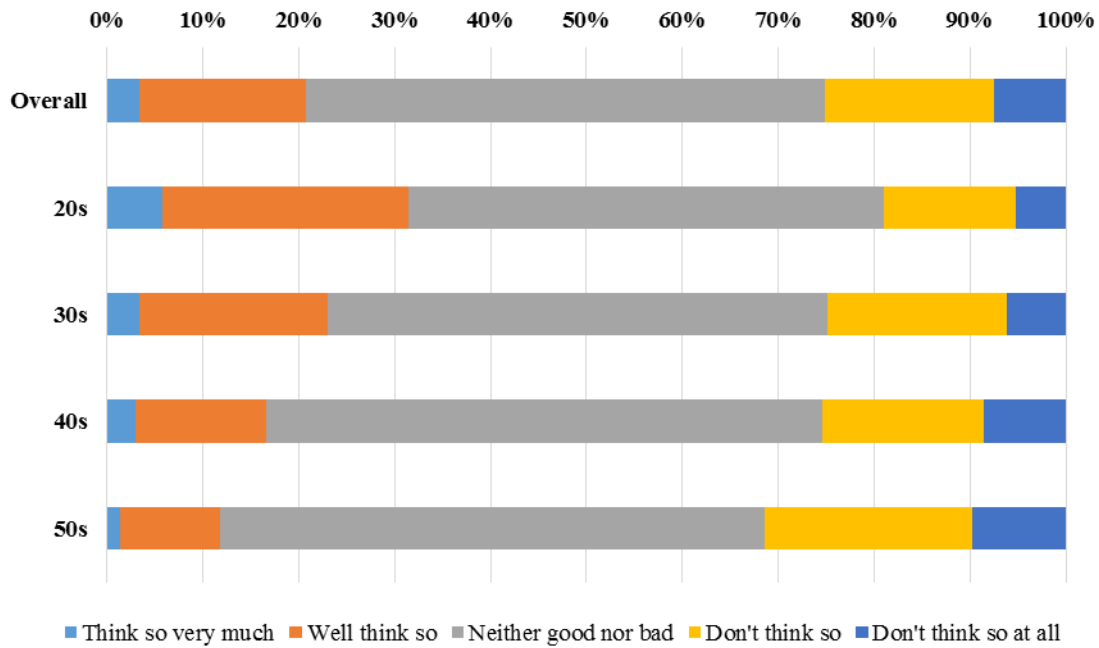


Fig. 2 Consumer awareness of genetically modified/genome-edited foods

In December 2021, a web survey was conducted with 250 men and women in their 20s to 50s across Japan (total of 2000 people).

Based on reference 9).