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Article Review

Effect of Genetic Engineering on Plant Organs of Food Products

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Abstract

Genetic engineering has changed the landscape of agriculture and food production by creating genetically modified organisms to achieve desired traits. This article presents a review of the effects of genetic engineering on plant organs used in food production. This technology has enabled increased productivity, pest and disease resistance, and improved nutritional quality in food crops. In addition, the use of GM crops can also reduce yield losses and pesticide use, thus having a positive impact on the environment and human health. This study is to find out about the effect of genetic engineering on plant organs for food products. The method used in this study is a literature review by exploring data and information from articles collected from various sources. The sources of data and information are to gain an understanding of the effect of genetic engineering on plant organs of food products which include articles in journals and working papers in hard copy. Based on the results we can create transgenic plants that have new properties, such as resistance to insects, pests, herbicides, or harsh environmental conditions.

Keywords: *Genetic Modification, DNA, and PRGs*

INTRODUCTION

Genetics, derived from the Greek word γένvω or genno meaning "to give birth," is an important branch of biology today. It focuses on the study of trait inheritance and trait variation in different types of organisms, including suborganisms such as viruses and prions. In summary, genetics can be defined as the study of genes. The term "genetics" was first introduced by William Bateson in a personal letter to Adam Chadwick, and the term was used officially at the third International Conference on Genetics in 1906. The scope of genetics is vast, ranging from the molecular level to the population level. In more detail, genetics seeks to explain the genetic material that carries heritable information, the way genetic expression occurs, the process of genetic inheritance from one individual to another, and why variation occurs among individuals in a population or genetic diversity.

Genetic engineering is the process of transferring one gene to another, either between genes within one organism or between different organisms, with the aim of producing products that benefit living things. In the beginning, genetic engineering was mainly used in crops to solve the problem of global food shortages. . Over time,

this technology has evolved and is not only applicable to plants and animals, but has also involved humans and crossbreeds. The basic principle of genetic engineering is to manipulate the nucleic acid structure of DNA to change the genetic composition of the recipient organism, including the addition of genes from other organisms. Biotechnology is an unconventional plant breeding method that can be used to improve the quality of plant breeding (Devi Artanti et al., 2010) . Biotechnology, a field of science that uses living organisms or products of living organisms in the framework of production to create various types of products. The application of biotechnology has been used to create foods that have advantages in terms of nutrition, taste, functional properties, shelf life, and other characteristics or characteristics. (Atma et al., 2018) .

Genetic engineering has significant benefits in human life, such as increasing food production with larger quantities and superior quality. Genetically engineered products often have higher nutritional content, better resistance to weather and pests, and can increase crop yields. However, there are also negative impacts that need to be considered. One of the negative impacts is the potential for diseases or health problems due to new chemicals present in the genetically modified product or in the GMO product. This can cause new diseases or trigger pre-existing diseases. Therefore, genetic engineering is a subject of controversy in society. (Anisatul & Lailatus, 2019) . (Estiati & Herman, 2016)

Genetic engineering technology has experienced rapid development and benefits, especially in producing Genetically Engineered Products, such as transgenic plants used in food production. Food produced from Genetic Engineering Products is known as Genetically Engineered Food. Before Genetically Engineered Products are introduced to the market, a food safety assessment is conducted to assess their potential negative impacts that may threaten human health. Therefore, it is important to have guidelines governing the food safety assessment of Genetically Engineered Products. Hunger and food crisis are serious concerns today. The International Food Agency reports that food reserves on the world market have reached their lowest level since the 1980s, having decreased by five percent compared to the previous year. This is a concern because the impact will be felt by people living below the poverty line. Food shortages can lead to rising prices of basic commodities, which are difficult for the poor to access.

Food recovery can be done by conventional methods or by using biotechnology, particularly genetic engineering technology. Conventional methods involve crossing plants, but often produce undesirable genes and take a long time. Biotechnology, including genetic engineering, has been used for centuries in plant and animal breeding, as well as in food production. While biotechnology has provided significant benefits in sectors such as agriculture, food, health and the environment, there are also concerns regarding its risks and negative impacts, including ethical, environmental and religious issues. Genetic engineering has its own problems, such as genetically modified organisms that have defects and shortcomings. Therefore, there needs to be regulations governing genetic engineering to ensure biosafety and human health. The legal regulation of genetic engineering in Indonesia has been a source of moral controversy due to different views in society on the moral aspects associated with genetic engineering.

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RESEARCH METHODS

The method used in this study is a literature review by exploring data and information from articles collected from various sources. The sources of data and information are to gain an understanding of the effects of genetic engineering of plant organs on food products, which include articles in journals and working papers in hard copy.

RESULTS AND DISCUSSION

Genetic Engineering

Genetic engineering is the process of transferring one gene to another, either between genes in one organism or between different organisms, with the aim of producing products that are beneficial to living things. Genetic engineering can be simplified as the process of transferring genetic material from one species to another or transferring chemically created genes to certain species (Budianto, 2000) . In the beginning, genetic engineering was mainly used in crops to overcome the problem of global food shortages. Over time, this technology has evolved and not only applies to plants and animals, but has also involved humans and cross species. The basic principle of genetic engineering is to manipulate the structure of DNA nucleic acids to change the genetic composition of the recipient living being, including the addition of genes from other living beings.

Genetic engineering has significant benefits in human life, such as increasing food production with larger quantities and superior quality. Genetically engineered products often have higher nutritional content, better resistance to weather and pests, and can increase crop yields. However, there are also negative impacts that need to be considered. One of the negative impacts is the potential for diseases or health problems due to new chemicals present in the genetically modified product or in the GMO product. This can cause new diseases or trigger pre-existing diseases. Therefore, genetic engineering is a subject of controversy in society. (Anisatul & Lailatus, 2019)

Genetic engineering technology, also known as DNA technology, is used to improve plant characteristics through genetic modification. The goal is to produce plants that have new and improved traits. DNA technology develops and uses techniques to isolate and transfer genes of a desired trait to a plant that becomes transgenic. Using DNA technology, we can create transgenic plants that have new traits, such as resistance to insects, pests, herbicides or harsh environmental conditions. Transgenic crops that are resistant to insects and pests are already widely grown and sold in various countries. In Indonesia, the development of transgenic crops is ongoing, with the most recent developments being the release of transgenic sugarcane in East Java and transgenic rice in West Java (Susilo, 2019) .

Types of Plant Organs

It is expected that the transformed genes will produce or express products that have added value to humans. One example of a product that is produced in large quantities is transgenic plants. Specific genes that have superior characteristics are inserted into the plant, thus creating the desired trait (Herlanti, 2014) . Genetic modification of plants for food production has become a controversial topic in recent years. While there are many examples of plants that are genetically modified (GM) for this purpose, here are some types of plant organs that are commonly genetically modified for food production:

1. GM Rice Crops
   Rice is one of the world's major food crops, and several rice varieties have been genetically modified to increase yield, resist pests, or have other desirable traits.
2. GM Corn Crops
   Corn is an important food source and raw material. GM maize is often modified to be resistant to pests, resistant to certain herbicides, or have other properties such as the ability to produce additional protein.
3. GM Nuts
   Several legume species such as soybean and mung bean have been modified to improve seed production and quality, as well as resistance to pests and diseases.
4. GM Tomatoes
   Tomatoes are a common vegetable fruit in many diets. GM tomatoes can be modified to increase shelf life, disease resistance, or other characteristics such as size and shape.
5. GM Cassava and Sweet Potato
   Root crops such as cassava and sweet potato are often modified to increase yield, reduce damage during storage, and resist pests.
6. GM Cabbage
   Cabbage is often used in a variety of dishes, and GM cabbage has been modified to be resistant to pests such as cabbage borer caterpillars.
7. Golden Rice
   Golden Rice is a variety of rice genetically modified to produce beta-carotene (provitamin A) in the grain. It is an attempt to address the problem of vitamin A deficiency in some countries.

Benefits and Risks of Genetic Engineering in Food Products

Genetic engineering in food production has a number of significant benefits, which involve improving the quality, productivity and sustainability of agricultural systems. The following are some of the key benefits of genetic engineering in food production:

1. Productivity Improvement
   Genetically modified crops can often produce greater yields in limited land availability. This helps address the problem of hunger and food shortages in different regions of the world by increasing the amount of food production.
2. Improved Nutritional Quality
   Genetic engineering can be used to improve the nutritional quality of food crops. For example, Golden Rice is a rice variety genetically modified to produce beta-carotene (provitamin A), which is important for eye and immune

system health. This helps address the problem of vitamin A deficiency in some countries.

3. Resistance to Pests and Diseases
   Genetically modified crops can be made resistant to certain pests and diseases. This can reduce farmers' dependence on chemical pesticides that can damage the environment and human health.
4. Increased Tolerance to Environmental Factors
   GM crops can be designed to be more resistant to extreme environmental conditions, such as high temperatures, drought or nutrient-poor soils. This helps increase the stability of agricultural yields in the face of increasingly volatile climate change.
5. Deduction of Loss of Yield
   GM crops that are resistant to pests and diseases can reduce yield losses due to attacks by pest organisms such as caterpillars or plant diseases. This results in greater yields and better quality.
6. Pesticide Use Reduction
   GM crops that are resistant to pests often require the use of fewer pesticides, which has a positive impact on the environment and human health.
7. Improved Food Availability
   With increased productivity and resistance to environmental factors, GM crops can help increase global food availability, reduce hunger and support the sustainability of food systems.
8. Improved Farmer Economy
   With better yields and reduced costs, farmers who adopt GM crop technologies can increase their income and improve their living standards.
9. Reduction of Environmental Pollution
   GM crops that require less pesticide use can reduce environmental pollution by agricultural chemicals.
10. Land Use Reduction
    Increased crop productivity can help reduce pressure on forests and other natural ecosystems that are often converted to agricultural land.

While there are great benefits associated with genetic engineering in food production, it is also important to consider the ethical, social and environmental issues associated with this technology. The use of GM crops should be strictly regulated, and constant evaluations should be conducted to ensure the safety and sustainability of their use.

Risks of Genetic Engineering in Food Products

Every technology has risks, including recombinant DNA technology that produces genetically modified organisms (Genetically Engineered Products). It is impossible to completely eliminate risk (zero risk) in this context. Therefore, it is necessary to form a consensus or mutual agreement in a calm and rational atmosphere to deal with genetically engineered products, especially in regulating their biosafety before they are introduced to the public. A complete rejection and non-acceptance of a technology is not beneficial, because such actions can hamper our chances of taking better and safer measures (Deswina, 2009) . Genetic engineering in food production has potential risks that need to be seriously considered. While this technology has significant benefits, there are some potential issues that need to be considered. Here are some potential risks of genetic engineering in food production:

1. Environmental Impact:
   a. Pest and Disease Resistance
      Although GM crops are often modified to be resistant to pests and diseases, this resistance can give rise to new pests or diseases that are more difficult to control.
   b. Genetic Contamination
      GM crop genetics can transfer to conventional crops or related wild plants, altering natural populations and biodiversity.
   c. Biodiversity Loss
      A focus on a few highly productive GM crop varieties could reduce crop biodiversity, which could lead to long-term ecological and resilience issues.
2. Allergy Potential and Toxicity:
   a. Allergies
      The introduction of new proteins or changes in nutritional composition can lead to unwanted food allergies.
   b. Toxicity
      Some GM crops produce proteins that are not present in the original plant and may have toxic effects if consumed by humans or animals.
3. Overuse of Pesticides:
   a. Sustainability
      Some GM crops that are resistant to certain pests and herbicides may encourage the overuse of pesticides, which can have negative impacts on the environment and human health.
4. Ethical and Social Issues
   a. Market Control by Large Companies:
      The adoption of GM crop technology may lead to a concentration of power in the food and agriculture industry in the hands of a few large companies.
   b. Farmer Dependency
      Farmers who depend on GM seeds owned by certain companies can feel trapped in a cycle of economic dependency.

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5. Long-term Security Uncertainty
    a. Long-term Effects
       The long-term effects of GM crops on human health and the environment may not be fully known. Therefore, there needs to be careful research and monitoring when introducing new GM crops.
6. Cross Contamination
   Unintended Genetic Transfer GM crops can transfer genes to wild or conventional crops through cross-contamination, undesirably altering their genetic traits.
7. Food Safety Issues
   Lack of Food Safety Investigation: There are concerns that investigations into GM food safety may not be sufficiently in-depth or independent, which could result in a non-objective assessment of risk.

It is important to remember that many countries have strict regulations in place regarding the testing, approval and use of GM crops. The aim is to identify, mitigate and manage potential risks associated with this technology. Food safety, environmental sustainability and ethical considerations should be an integral part of the debate on the use of genetic engineering in food production.

Change in Production Yield

Genetic engineering of crops can have an influence on the organoleptic properties, such as flavor, aroma, and texture, of food products. These effects can vary depending on the type of genetic modification performed and the desired traits in the crop. The following are some examples of the changing influence of crop engineering on the organoleptic properties of food produce:

1. Changes in Taste
    a. Increased Sweetness
       Genetically modified crops can produce sweeter fruits or vegetables due to increased sugar content.
    b. Bitter Taste Reduction
       Some food crops can be modified to reduce certain bitter flavors, making them more palatable.
2. Changes in Scent
    a. Aroma Improvement
       Genetic modification can increase the production of certain aroma compounds, which can enrich the flavor of food products.
    b. New Scent Creation
       Genetics can be used to create plant varieties with unique aromas not found in conventional varieties.

3. Changes in Texture
    a. Violence Control
       Some food crops, such as fruits, can be modified to have a softer or crunchier texture, according to consumer preferences.
    b. Increased Resilience to Pollution
       Genetically modified crops can have a more durable texture, making them more resistant to physical damage and disease.

It is important to remember that changes in the organoleptic properties of genetically modified crops must be carefully considered and tested before the food product can be accepted in the market. Consumers often have strong preferences for the taste, aroma, and texture of food, and significant changes in these properties can affect product acceptance. Therefore, sensory tests and consumer research are often conducted to evaluate the impact of genetic engineering on food organoleptics.

Effect of Genetic Engineering on Food Products

Genetic engineering can have a significant effect on plant organs used for food production. Genetic engineering technology allows scientists to genetically modify organisms by inserting or changing certain genes to achieve desired traits. In the future, the role of biotechnology focusing on molecular biology and genetic engineering is believed to be the main choice in addressing various problems related to health, medicine, agriculture, food, energy and the environment. The ultimate goal is to improve people's welfare and achieve national independence (Tajuddin, 2010) . In the context of food production, this can have various impacts and influences, both positive and negative, depending on how the technology is used. Here are some of the effects of genetic engineering on plant organs of food products:

1. Productivity Improvement
   One of the main goals of genetic engineering in food production is to increase crop productivity. Genetically modified organisms can produce greater yields, solving the problem of hunger and food shortages in some regions.
2. Resistance to Pests and Diseases
   Genetically modified crops are often designed to be resistant to certain pests and diseases. This reduces farmers' dependence on chemical pesticides that can damage the environment and human health.
3. Improved Nutritional Quality
   Genetic engineering can be used to improve the nutritional quality of food crops. An example is Golden Rice, which was modified to produce beta-carotene (provitamin A) to overcome vitamin A deficiency.
4. Deduction of Loss of Yield
   GM crops that are resistant to pests and diseases can reduce yield losses due to pest organism attacks, increasing the yield available for consumption.
5. Pesticide Use Reduction
   GM crops that are resistant to pests often require the use of fewer pesticides, which has a positive impact on the environment and human health.
6. Increased Resilience to Environmental Factors
   Some GM crops are designed to be more resistant to extreme environmental conditions, such as high temperatures, drought, or nutrient-poor soil.

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7. Reduced Dependence on Seeding Substances
   Some GM crops produce seeds that are more robust and resistant to changing environmental conditions, reducing farmers' dependence on expensive seeding agents.
8. Reduction of Environmental Pollution
   GM crops that require less pesticide use can reduce environmental pollution by agricultural chemicals.

However, the use of genetic engineering in food production also comes with debates and potential risks, such as environmental concerns, ethics, and socio-economic impacts. Therefore, the use of GM crops is often tightly regulated by governments, and careful safety evaluations are required before GM crops can be used commercially. These evaluations include assessments of impacts on the environment, human health, and agricultural sustainability.

PRG (Genetically Engineered Product) Food Safety

Genetically Engineered Products (GEs) are the result of the implementation of the latest biotechnology technology. According to the Government Regulation of the Republic of Indonesia No. 21 of 2015 on Biosafety of Genetically Engineered Products, PRGs are described as living organisms, their parts, or processed products that have new genetic sequences produced through the application of modern biotechnology technology (Estiati & Herman, 2016) . The Indonesian government implemented Government Regulation 21/2005 on Biosafety of PRGs, which requires the implementation of a strict monitoring and control system in regulating approved PRG seeds (Kurniawan & M. Rondhi, 2020) . The policy of developing Genetically Engineered Organisms (GEOs) must be implemented carefully, including through biosafety testing. Biosafety assessments are a global concern and are required by the Cartagena Protocol that applies to countries using PRGs (Swastika & Hardinsyah, 2008) .

The development of food products through genetic engineering has provided several benefits, such as reduced product prices and improved durability, storage or nutritional value. However, it should be kept in mind that in addition to the benefits, there are also risks associated with their impact on human health. Therefore, preventive measures, whether in legal, administrative or technical aspects, are needed to ensure food safety. This involves a precautionary approach in assessing biosafety and food.

Genetically modified food safety assessment generally covers several aspects, such as:

1. Direct health effects (toxicity).
2. Potential to cause allergic reactions (allergenicity).
3. Identify specific components that may have nutritional or toxic properties.
4. Stability of the inserted gene.
5. Effect on nutritional value as a result of genetic modification.

6. Other possible undesirable effects that may arise due to gene insertion.

Some concerns about genetically modified food products

1. Potential to cause allergic reactions (allergenicity)

   Gene transfer from allergenic foods into genetically engineered products is undesirable unless it can be demonstrated that the resulting proteins are not allergenic. While conventional foods are generally not tested for allergenicity, genetically engineered products have undergone testing protocols evaluated by FAO and WHO, and to date, there have been no reports of allergic effects associated with genetically engineered products on the market.
2. Gene transfer

   The potential transfer of genes from genetically modified products into the body or bacteria in the digestive system is a cause for concern, especially if the genes are resistant to antibiotics. Although the possibility is very small, experts from FAO/WHO recommend the use of technologies without antibiotic-resistant genes.
3. Outcrossing

   Gene transfer from GM crops to conventional crops or related species in nature (outcrossing) can have indirect impacts on food safety and food security. Some countries have adopted strategies to avoid such mixing by separating farmland for GM crops and conventional crops.

The food safety assessment of genetically modified products must be carried out individually for each case, as each genetically modified organism has different inserted genes and is inserted by different methods. Therefore, it is important to evaluate the safety of each genetically modified product specifically and it is not possible to make general statements about the safety of all genetically modified products. According to the WHO, genetically modified food products on the international market have undergone risk evaluation and are unlikely to pose a risk to human health. Nonetheless, the precautionary principle is still required, just as in the case of conventional food products, such as those containing allergens.

Ethical and Regulatory Aspects of Genetic Engineering in Food Crops

Ethics deals with moral philosophy, not of facts, but of values; not of human actions or deeds, but of ideas. Ethics is part of the study of axiology which deals with ethical and aesthetic issues. Ethics or moral philosophy becomes the standard basis for judging one's behavior or actions. Scientific ethics aims to apply moral principles, regarding what is considered good, and in the context of scientific behavior, being able to avoid what is considered bad (Rahmayumita, 2022) .

Recent advances in modern biotechnology in the field of plant genetic engineering have become an environmental concern, along with cases of water, soil and air pollution caused by pesticide residues. This is due to the allegation that products of genetic engineering may produce toxic substances that could potentially harm human health and may also disrupt the balance of the ecosystem. Therefore, to prevent major risks to humans and environmental damage that may be caused by genetically engineered products, it is important for any developer of agricultural biotechnology activities to comply with environmental ethics and apply the principles of environmental ethics as a preventive measure.

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1. Principles of Environmental Ethics

   The principles of environmental ethics are formulated with the aim of providing guidelines and guidance for human actions in living a life in harmony with nature, including direct behavior towards nature itself and behavior towards fellow humans that has a certain effect on the environment. These principles of environmental ethics can also be used in a broader context, namely in the implementation of development that focuses on the maintenance and sustainability of the environment.

2. Human Safety and Health

   One of the key aspects of genetic engineering regulation is ensuring human safety and public health. Genetically modified crop products must go through a rigorous risk assessment to ensure that they do not harm human health when consumed.

3. Intellectual Property Rights

   Genetic engineering involves the use of advanced technology, and this raises ethical questions regarding intellectual property rights. Patents and other intellectual property rights must be carefully regulated to ensure that inventions and innovations involving genetic engineering are recognized and rewarded.

4. Social Responsibility

   Companies and researchers involved in the development of genetic engineering must be socially responsible. They should consider the social impact of their products and strive to minimize negative impacts.

5. Ethical Restrictions

   There are also ethical considerations related to the limits to the use of genetic engineering. For example, whether the use of genetic engineering in altering crop traits to increase agricultural yields will lead to unequal access to resources.

Adequate regulations should be designed to ensure that all these ethical aspects are taken into account in the development, testing and use of genetically modified crops. This must be done to maintain a balance between the agricultural innovation needed to feed the world and the protection of human health, the environment and social justice.

"Golden Rice" Case Study

Golden Rice was developed with the aim to address the issue of vitamin A deficiency, which is a serious global health problem, especially in developing countries where people rely on less diverse diets. Vitamin A deficiency can cause serious health problems, including childhood blindness and other common health problems. Scientists are using genetic engineering technology to produce rice varieties that contain high concentrations of provitamin A (beta-carotene). Beta-carotene is the precursor of vitamin A in the human body. By consuming Golden

Rice, it is hoped that people with vitamin A deficiency can increase their nutritional intake and overcome related health problems.

1. Positive Influence
a. Golden Rice has successfully increased provitamin A intake in areas suffering from vitamin A deficiency.
b. This helps reduce the risk of blindness and other health problems caused by vitamin A deficiency.
c. In the long run, this can improve the welfare and quality of life of people in the affected areas.
2. Negative Influence:
a. There are concerns that Golden Rice could trigger genetic mixing with other rice varieties in nature (outcrossing), which could alter the genetic diversity of rice plants and ecosystems.
b. Some groups and individuals consider the use of genetic engineering in addressing nutrition to be a controversial human intervention.
3. Risk Management

To manage potential negative impacts, strict regulations have been implemented on the spread and use of Golden Rice. In addition, research is ongoing to understand the long-term impacts of using this variety on human health, the environment and genetic diversity. The Golden Rice case study is an example of how genetic engineering in plant organisms can have significant impacts on food products and human health. It illustrates that this technology has the potential to address global nutrition issues, but also faces challenges related to ethics, regulation and risk management.

CONCLUSION

Genetic engineering has had a significant impact on food production by altering the traits of plant organs used in agriculture. Some of the positive impacts include increased productivity, resistance to pests and diseases, improved nutritional quality, reduced yield losses, reduced pesticide use, increased food availability, and reduced environmental impact. However, there are also potential risks to consider, such as adverse environmental impacts, potential allergic reactions, and food safety concerns.

The importance of food safety evaluation of genetically modified products cannot be overlooked. Careful testing is required to ensure that these products are safe for human consumption. Biological and environmental safety should always be prioritized in the development and use of genetic engineering in agriculture and food production. In addition, the use of genetic engineering in food production also needs to be accompanied by strict regulations to ensure that these products meet established safety and quality standards.

The involvement of various parties, including governments, scientists, farmers and consumers, is crucial in making decisions related to genetic engineering in agriculture and food production. In the face of the challenges of global hunger and climate change, genetic engineering can be a useful tool in increasing food production and reducing environmental impacts. However, it is important to remember that every step in the use of this technology must be done carefully, based on strong scientific evidence, and always with the safety and well-being of people and the environment as the top priority.

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