A Review on Societal Impacts of Recombinant DNA Technology

Haripriya Sureshbabu* and Ridhin Chandran**

Department of Biotechnology V.G. Shivdare college of Arts, Commerce and Science, Solapur

**University of Essex, UK

Abstract:

In this Hustle-Bustle lives of humans, there is an abundant ignorance on their mental and physical health which gave birth to a variety of known and unknown diseases. To improve human health much more in terms of food and medicine genetically with the advancement of genetic engineering especially recombinant DNA technology. Different studies throughout the years showed how Recombinant DNA technology can be applicable in a wide range of fields like Agriculture, medicine, research and so on. Recombinant DNA technology which involves the introduction of foreign gene into the DNA that leads to the development of Genetically Modified Organisms (GMO) with improved quality needed to shape up a healthy society. A diverse number of recombinant products and GMOs have been engineered like transgenic cow, transgenic mice. Transgenic sheep, transgenic plants, transgenic insects that play a crucial role in medicine, agriculture, research, textiles and industries in one way or another. Recombinant DNA technology can be performed using multiple tools and techniques which enhances its efficiency yielding a better and useful product. When a method is discussed based on its pros, comes the cons of recombinant DNA technology which is an underrated concept that is rarely mentioned. The exploitation of recombinant organisms and products for several purposes have led to wide catastrophes that had the potential to turn the human kind upside down. These exploitations from all the over the world caused the well-known advanced Recombinant DNA technology a dangerous and useful method depending upon on what kind of hands they fall.

Keywords: applications, cons, genetically modified organisms, Recombinant DNA technology, recombinant products, transgenic animals, transgenic plants.

Introduction

The modern society has been affected by various factors like food deficiency and malnutrition, an increase in the health problems, environmental crisis and so on (Shinde et al., 2018). With the elevating population rates, these factors are going to be a great threat (Shinde et al., 2018). The traditional approaches including breeding, traditional medicines, and degradation of pollutants using ordinary techniques used to overcome this made little change (Shinde et al., 2018). When genetic engineering came into light, modern methods and tools has been exploited for the welfare of the society (Shinde et al., 2018). One of the technologies used in the modern era is the recombinant DNA technology which plays an important role in improving the health and lifestyle of human beings.

Literature Review

During the past century, the recombinant DNA technology wasn't believed to be a technology that can improve the desirable characteristics in an organism depending on the interest (Khan et al., 2016). In this 21st century, this technology showed that its worth improving different fields of research. A wide range ofapplications of this technology can be observed for instance, enhancing the quality of food, modifying crop plants in agriculture and production of several therapeutic products (Khan et al., 2016). Because of such vast applications, it is necessary to investigate it more deeply with utmost interest.

Some recombinant products are utilized in human therapy (Shivanand and Noopur, 2010). The first purpose where the recombinant DNA technology has been utilized is in the synthesis of human insulin (Shivanand and Noopur, 2010). Banting and Best discovered insulin hormone which controls the sugar levels which was secreted by the β-cells of pancreas (Shivanand and Noopur, 2010). Diabetic patient whose insulin production is diminished, can be treated with the insulin which is produced from the pancreas glands of abattoir animals (Shivanand and Noopur, 2010). Bovine and porcine insulin is homologous to human insulin but tend to produce some antibodies against it (Shivanand and Noopur, 2010). Escherchia coli which is a much more dependable and convenient method (Shivanand and Noopur, 2010). Another application of this technology is the production of transgenic animals which is also called as genetically modified organisms (GMO) which plays an important role in many fields, especially helped the animal breeders to enhance the quality of commercial goods obtained from livestock.

Creation of Transgenic insects are the next milestones in the field of recombinant DNA technology (Wimmer, 2003). An efficient method was introduced in 1982 in which an exogenous DNA was integrated into the insect genome that will be inherited in the following generations of insects as a transgene (Wimmer, 2003). The first attempt of genetic

transformation was performed in the fruit fly Drosophila melanogaster with the help of P element, a transposable element (Ashokan, 2007). The necessity for the development of transgenic insects gave rise to variety of applications like transgenic insects as bioreactors, transgene improved biocontrol agents, impairing disease transmission, which can be beneficial for the society (Ashokan, 2007). The first application of GMO as bioreactor is used for the production of human skin protein; type III procollagen is genetically engineered silkworms whose application is to make artificial skin (Ashokan, 2007). Using conventional insecticides will kill the pests that destroy the yields of farmers (Ashokan, 2007). These pesticides will harm the beneficial organisms whose role is to enhance the soil fertility thereby raising the productivity (Ashokan, 2007). Different researchers studied on modifying the beneficial organisms that have the potential to withstand the effects of insecticides (Ashokan, 2007). The development of genetically modified organisms in terms of impairing disease transmission is another well-known application that is been a topic of discussion (Ashokan, 2007). Insects specifically mosquitoes are responsible for spreading number of diseases like malaria, yellow fever etc. that deteriorate Human health (Ashokan, 2007). Scientists then succeeded in making genetically modified mosquitoes which have the potential to over express which will help in neutralizing the parasites in the stomach or salivary glands of the disease-causing insects (Ashokan, 2007). Following are the examples of genetically engineered insects and its potential applications.

Image source: Asokan, R. (2007). Genetic engineering of insects. Resonance, 12, 47-56.

Box 4. Some Genetically Engineered Insects and their Potential Applications

Insect	Potential applications
1. Pink boll worm, *Pectinophora gossypiella*	* Autocidal biological control
2. Mediterranean fruit fly, *Ceratitis capitata*	* Biased sex ratio toward male * Pest eradication
3. Phytoseiid mite, *Metaseiulus occidentalis*	* Biological control programme
4. Nematode, *Heterorhabditis bacteriophora*	* Improved temperature tolerance
5. Mosquito, *Anopheles*, *Aedes*	* Possible vaccine delivery system * Interruption of virus life cycle to prevent multiplication and dissemination * Long term changes in the blood feeding behaviour of mosquitoes
6. Honey bee, *Apis* sp	* Improved yield of honey * Enhanced pollination * Resistance to viral and parasitic diseases
7. Silk worm, *Bombyx mori*	* Improved silk properties * Bioreactor for heterologous protein production * Resistance to viral and parasitic diseases
8. Fruit fly, *Drosophila melanogaster*	* Model organism for transformation studies
9. Insect parasitoids and predators	* Increased egg laying * Enhanced mass production * Improve host searching * Resistance to insecticides

Transgenic animals are developed when a foreign gene (transgene) is inserted into the genome of the concerned animals (Blundell, 2006). Transgenic animals developed can modify the quality and quantity of milk by increasing the protein content and the amount of milk being produced. The animals used in the milk production are mostly cattle, goats and sheep (Shakweer et al.,2023). Among the transgenic animals, the transgenic mice can be used massively as an animal model to understand the human diseases which can also help in the production of therapeutic products (Satyanarayana, 2011). The transgenic mice whose immune system is homologous to humans is a merit for immunologists to work on AIDS (Satyanarayana, 2011). Moreover, these GMOs were also used to study diseases like Alzheimer's and cancer which is among the widely spread diseases with a huge health toll (Satyanarayana, 2011). Transgenic mice in the field of cancer study were used to track its progressing modalities for cancer therapy (Satyanarayana, 2011). Transgenic experiments when carried out in sheep and cows involve the development of mammary glands which would help in the generation of several proteins by acting as a bioreactor (Satyanarayana, 2011). In order to improve wool quality and quantity, transgenic sheep were developed which would produce cysteine that will get synthesized from bacterial genes thereby improving the keratin, the prime factor in wool (Satyanarayana, 2011). An important tool in the disease diagnosis is the monoclonal antibodies which is being produced by one technique called hybridoma technology which is another unavoidable application of recombinant technology, used for the treatment of autoimmune as well as infectious diseases (Satyanarayana, 2011).

Transgenic plants are the genetically modified plants in which the transgene is introduced into the nucleus of the plant cell either by using the micro-projectile bombardment method (gene gun) or by agrobacterium method (Rani and Usha, 2013). These techniques are performed to increase the productivity of crops (Rani and Usha, 2013). The major pros obtained from genetically modified plants is the improved crop yield, longer shelf life, better quality, pest resistance, pH and heat tolerance, temperature resistance and resistance to stress (Rani and Usha, 2013). These traits largely benefitted the farmers, they managed to cut down the cost at the same time received fruitful harvest throughout the year (Rani and Usha, 2013). These mentioned applications are a few examples of the approach and social impacts of recombinant DNA.

The basic tools needed to perform Recombinant DNA technology are the enzymes, host organism, exogenous DNA and the vectors that are going to act as the vehicles for the same (Hunter and Strickland, 2018). The first basic step in this technology is the integration of exogenous DNA into the genome of host organism with the help of the first tool restriction enzymes namely endonucleases and exonucleases (Hunter and Strickland, 2018). These enzymes cut the DNA at a specific site called Restriction site leading to the formation of blunt

or sticky ends depending upon the type of restriction enzymes (Hunter and Strickland, 2018). After cutting, they need to be ligated to the exogenous DNA with ligase enzyme (Hunter and Strickland, 2018). The second tool that is used for the process is vectors which is going to act as the vehicle for the transport of interested gene into the host genome (Hunter and Strickland, 2018). These vectors mainly are plasmids and bacteriophages with origin of

replication, a selectable marker and cloning site (Hunter and Strickland, 2018). The last and crucial tool is the host organism into which the transgene or the recombinant DNA is inserted. (Hunter and Strickland, 2018) Depending upon the need and interest of researchers, healthy host organism should be selected. Using these tools, wide techniques are available for the insertion of foreign DNA into the host genome like Particle Bombardment method, Microinjection method, electroporation and so on (Ashokan, 2007).

Although Recombinant DNA technology has revolutionized medicine and agriculture enhancing the health care and food security, however several ethical concerns regarding gene manipulation did arise. The notable issue in the production of veterinary vaccines produced from Recombinant DNA technology is the cost per dose and combining the factors that needed to make an effective vaccine of a certain type is quite hectic and difficult (Deb et al.,2016). A diverse consequence can be found when DNA is integrated into the host genome like malignancies, hereditary complications and so on (Deb et al.,2016). Newly created pathogens via recombinant DNA technology could cause worldwide epidemics, unintended consequences leading to fatal ecological imbalances and risk of misuse of new tools for bio-terrorism were some of the controversial topics regarding the potential biohazards of Recombinant DNA technology (Grobstein, 1977)

Conclusion

A very powerful and yet dangerous technique called the recombinant DNA technology with multiple variety of applications that can improve the health of human lives in terms of clothing, medicine, agriculture and other products. On the other hand, with lots of applications hold another side of this technique which is a bit dangerous that has the ability to turn the human kind upside down. The technique involves the usage of basic tools for the production of genetically modified organisms (GMO) and different ways how an Exogenous DNA can be integrated into the genome of healthy host. The pros and cons of this technique lies not in the method or ways but on the hands, they use and whether it is exploited for the welfare of society or for the destruction.

References:

1.Asokan, R. (2007). Genetic engineering of insects. Resonance, 12, 47-56.

2. Deb R., Chakraborty, S., Sengar, G., & Bhanuprakash, V. (2016). Pros and Cons of recombinant DNA technology in animal diseases diagnosis, prevention and control. Journal of Pure and Applied Microbiology, 10(1), 451-463.

3.Hunter, V., & Strickland, F. (2018). Applications of Recombinant DNA Technology. Scientific e-Resources.

4. Grobstein, C. (1977). The recombinant-DNA debate. Scientific American, 237(1), 22-33.

5. Khan, S., Ullah, M. W., Siddique, R., Nabi, G., Manan, S., Yousaf, M., & Hou, H. (2016). Role of recombinant DNA technology to improve life. International journal of genomics, 2016(1), 2405954.

6. Rani, S. J., and Usha, R. (2013). Transgenic plants: Types, benefits, public concerns and future. Journal of Pharmacy Research, 6(8), 879-883.

7. Shakweer, W. M. E., Krivoruchko, A. Y., Dessouki, S. M., & Khattab, A. A. (2023). A review of transgenic animal techniques and their applications. Journal of Genetic Engineering and Biotechnology, 21(1), 55.

8. Shinde, S. A., Chavhan, S. A., Sapkal, S. B., & Shrikhande, V. N. International Journal of MediPharm Research.

9. Shivanand, P., & Noopur, S. (2010). Recombinant DNA technology: Applications in the field of biotechnology and crime sciences. International Journal of Pharmaceutical Sciences Review and Research, 1(1), 43-49.

10.Wimmer, E. A. (2003). Applications of insect transgenesis. Nature reviews genetics, 4(3),225-232