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Role Of Plants In Molecular Pharming: An Empirical Investigation Of Experts' Opinion

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Abstract

Plants have moved way beyond their popular 'solitary' function of photosynthesis and are now being used as repositories for growing therapeutic molecules, industrial enzymes, and even vaccines. This innovative use of plants has the potential to revolutionise the pharmaceutical and biotechnology industries, offering a more sustainable and cost-effective way to produce essential drugs and treatments. These plant factories are able to produce recombinant proteins of interest at a much cheaper rate than animal cell cultures, owing to their high scale-up capacity. Furthermore, India, being a predominantly agroeconomic country, has the infrastructure and street knowledge of farmers who can cultivate these 'transgenic' crops like any other crop they have been cultivating for years. Scientists and researchers need to develop and stabilise the technology for the farmers to grow and cultivate, and finally for the consumers to enjoy. This plant molecular farming technology is not easy to achieve, and production platforms are still better suited to other techniques. With so many benefits also come challenges associated with the implementation of the technology that spends years in the laboratory itself. Therefore, there is a need to carefully examine the ethical consequences and potential risks before widespread adoption, as well as invest in training and education for those who will be employing and preserving the technology. The researcher had considered experts from molecular farming industry to know the role of plants in molecular farming and found that Proteins industrial enzymes and animal feed supplements are produced in plant systems, Plants are used as repositories to grow therapeutic molecules, industrial enzymes, and even vaccines etc.

Keywords- Plant Molecular Farming, Plant Molecular Pharming, Therapeutic Molecules, Industrial Enzymes, Transgenic Plants

Introduction

The ongoing global debate over weighing the costs and benefits of genetically modified crops and other transgenic plants has brought techniques like molecular farming to the common household. Everyone has their opinion, and rightly so. Spök (2007) highlighted the issue of molecular farming, which combines agricultural and medical biotechnology. Policymakers must balance the potential economic benefits of this technology with the fragility of the GMO issue in the EU. However, it is important to discuss the technology that enables the production of proteins that can be used in various industries. Molecular farming refers to the process of using plants or plant cell cultures as bioreactors or cell factories to produce valuable proteins, both pharmaceutical and non-pharmaceutical, that have commercial significance. The desired gene of our interest can be injected into plant nuclear or chloroplast genomes for transformation. This is done by techniques like 'agroinfiltration,' wherein the transgenic Agrobacterium medium containing the desired gene is directly infiltrated into the plant parts via a syringe or under vacuum. Alternatively, a biolistic gun or gene gun can be used for similar transformations (Tak et al., 2016).

Plant molecular farming has the capacity to revolutionise the production of valuable proteins with numerous applications that can be produced in a cost-effective and highly scalable manner. Vaccine antigens derived from plants have been shown to be effective in preventing infectious diseases, such as hepatitis B and human papillomavirus. Plant-derived antibodies can be applied to treat issues such as cancer and autoimmune disorders. Therapeutic and nutraceutical proteins include blood-clotting or thrombolytic factors, enzymes used in the treatment of Gaucher's diseases, antimicrobial lactoferrin proteins, and lysozyme enzymes. Non-pharmaceutical proteins produced in plant systems, such as industrial enzymes and animal feed supplements, can also be produced. For example, biofuels can be produced by the action of cellulose-breaking enzymes on plant by-products and other agricultural waste (Obembe et al., 2011)

The expansion of plant molecular farming requires collaboration across multiple scientific disciplines, including molecular biology, plant physiology, and bioprocessing. The public perception of genetically modified crops can negatively impact the acceptance of plant molecular farming due to concerns about their safety, environmental impact, and potential effects on biodiversity. The regulatory framework for genetically modified crops can vary widely across different countries and regions, making it a major barrier to commercialization. Additionally, intellectual property issues related to plant molecular farming must be addressed, as it involves creating novel genetic material that may be subject to patent protections. Finally, technical challenges, such as optimising protein expression and purification in different plant systems, need attention. (Basaran & Rodríguez-Cerezo, 2008).

Literature Review

Plants, like animal cells, have a secretory route that allows them to fold and construct complex proteins. The secretory pathway performs conformational changes such as glycosylation, amidation, hydroxylation, carboxylation, and sulfation. Glycosylation is important because differences in glycan structure between plants and mammals can modify the biological activity as well as the stability of a protein when it is injected as a drug. Plant molecular farming allows to produce glycoproteins with humanised sugar moieties as well as biobetters with altered glycan profiles to enhance efficacy, longevity, or streamline downstream processing (Tschofen et al., 2016). For this reason, multiple different plants and their parts can be used as factories for protein production. The use of multiple plants and their parts can be used as factories for protein production. Leafy parts of feed plants have gained much attention due to their high biomass and protein content, but protease action in mature leaves can reduce the yield. Different seed parts, such as the endosperm, cotyledons, can be targeted to synthesise long-lasting stable recombinant proteins), as well as non-feed crops such as tobacco (all year growth, substantial foliar biomass, large-scale infrastructure, and simple harvest methods), and Arabidopsis. Duckweeds and microalgae like Chlamydomonas reinhardtii are also being researched for their potential in molecular farming. The use of cell suspension cultures and hairy root cultures, which can be perpetuated indefinitely in liquid media under sterile conditions, is an innovative approach (Moustafa, Makhzoum, & Trémouillaux-Guiller, 2015).

Purification and extraction of recombinant proteins from plants is the most important aspect and also where most systems are currently lacking. If seeds were used as platforms, they would need to be fractionated to remove oil by dry or wet methods. The most commonly used method is mechanical disruption, such as homogenization or grinding of plant tissue, followed by centrifugation at high speeds to remove the supernatant from the pellet or vice versa. Pretreatment of extracts to optimise pH, ionic strength, composition of buffers, etc. increases the efficiency of purification steps. Numerous purification methods, like precipitation, hydrophobic interaction chromatography, ion exchange and affinity chromatography can be used. Non-chromatographic alternatives include oleosin-fusion methods and covalently bonded affinity ligand-based techniques. These methods have been used alone or in combination to achieve high-purity recombinant proteins (Wilken & Nikolov, 2012). The number and type of purification stages employed affect downstream processing costs for the extraction of plant-made recombinant proteins. The breakdown of costs between both stages of processing (upstream and downstream) heavily relies on the product's intended use, with industrial and biopharmaceutical proteins having completely different cost and purity spectra. A case-by-case analysis is required to determine the best plant production system, taking into account evaluation criteria like protein expression amount and stability, biomass production and storage stability, availability of commercially available tools for purification, biomass disposal costs, and byproduct revenues. It is also important to consider business drivers like capital spending, production scale and cost, market accessibility, and compliance standards (Wilken & Nikolov, 2011).

The pharmaceutical industry benefits the most from plant molecular 'pharming' techniques. Flotation centrifugation concentrates the protein while reducing the presence of endogenous seed proteins. Production of growth hormone, hirudin, apolipoprotein AI, and insulin e has been done by this technique to successfully purify a variety of pharmaceutical proteins as mentioned above. It was discovered that the insulin produced using this method was bioactively equivalent to commercially available human insulin produced by bacteria. Traditional fermentation techniques are not cost-effective for proteins that must be produced in large quantities on a regular basis, and transient expression in crops is not an option. Such proteins include HAS (‘human serum albumin’), topical lectins, and viral antigen-neutralising antibodies (Stoger et al., 2014). Another advantageous application, particularly for developing countries, is the production of edible vaccines. Transgenic potato and tomato plants have been used to develop edible vaccines against hepatitis B, type 1 diabetes, and cholera. Transgenic tobacco plants expressing the surface antigen of the HepB virus produced a primary response like traditional vaccines, but with better results when administered orally. Diabetes type 1 in mice was prevented by feeding them transgenic potato as well as tomato plants containing the GAD67 gene, which encodes diabetes-related proteins. Similarly, treatment of mice with transgenic potatoes that express the B subunit of the E. coli heat-labile enterotoxin (LT-B) prevented cholera in them (Bora, Gogoi, & Veer, 2016).

Plant molecular farming has more interesting applications that are not pharmaceutical or industrial in nature. Using recombinant mini-spidroins of major ampullate spidroin 1 and rMaSp2, researchers investigated the prospect of producing recombinant spider silk proteins in transgenic tobacco plants (Nicotiana tabacum). Chitin affinity chromatography and intein stimulation were used to purify the gelatin-like fluids (Peng et al., 2016). Because industrial proteins are required in large amounts, they should be produced at a low cost. Industrial enzymes are extremely important for various applications in industries such as food, textiles, and pharmaceuticals. Therefore, the development of cost-effective methods for their production is crucial for their widespread use. According to Xu et al. (2012), because of the lower cost of agricultural production, the protein stability of proteins localised in specific organs such as seeds, the scale-up simplicity and rapidity, and the potential of using crude plant materials explicitly in industrial processes, transgenic plants can be used to efficiently produce enzymes. Because of its high annual yield and relatively high seed protein content, maize seeds are considered as an appropriate platform to produce industrial proteins or enzymes. Corn-derived enzymes such as cellulases and xylanases that are involved in biomass conversion to synthesize biofuels such as ethanol are presently attractive commercialization prospectives. However, regulatory approval and widespread acceptance of transgenic plant field growth remain challenges.

Objective: To know the role of plants in molecular farming.

Methodology: The researcher had considered experts from molecular farming industry to know the role of plants in molecular farming. The survey was conducted with the help of a questionnaire. The researcher had collected the primary data through random sampling method and was analysed by statistical tool called mean.

Findings

Role of plants in molecular farming

S. No.	Statements	Mean Value
1.	Plants are used as repositories to grow therapeutic molecules, industrial enzymes, and even vaccines	3.12
2.	Plants or plant cell cultures are used as bioreactors or cell factories to produce valuable proteins	3.17
3.	Plant cells are able to produce recombinant proteins of interest at less cost than animal cell cultures	3.15
4.	Desired gene of our interest can be injected into plant nuclear or chloroplast genomes for transformation	3.16
5.	Plants are used to make antibodies which can be applied to treat issues such as cancer and autoimmune disorders	3.14
6.	Proteins industrial enzymes and animal feed supplements are produced in plant systems	3.13

Table above is showing different role of plants in molecular farming where the experts says that Plants or plant cell cultures are used as bioreactors or cell factories to produce valuable proteins with mean value 3.17, Desired gene of our interest can be injected into plant nuclear or chloroplast genomes for transformation with mean value 3.16, Plant cells are able to produce recombinant proteins of interest at less cost than animal cell cultures with mean value 3.15. The respondent also says that Plants are used to make antibodies which can be applied to treat issues such as cancer and autoimmune disorders with mean value 3.14, Proteins industrial enzymes and animal feed supplements are produced in plant systems with mean value 3.13 and Plants are used as repositories to grow therapeutic molecules, industrial enzymes, and even vaccines with mean value 3.12.

Conclusion

It is nothing short of magic that plants can be used as production systerms for proteins of mammalian or microbial origin. The ability to quickly respond to newly emerging infectious diseases by producing vaccines in a few weeks rather than months or years is one of the most intriguing prospects of plant molecular pharming. It has the probability to produce large quantities of therapeutic proteins at a lesser cost than conventional methods. There are many factors to consider when producing industrial proteins, including cost, stability, and scale-up potential. With vast applications in both medical and non-medical fields, the possibilities are endless and give plants a powerful hand in becoming eco-friendly factories. Furthermore, using plant-based proteins reduces reliance on animal-derived products and can contribute to a more sustainable and ethical manufacturing process. As a result, industrial proteins are an appealing option for businesses seeking to meet the growing demand for environmentally friendly products. However, regulatory, and public acceptance challenges must be overcome, particularly when using food and feed crops for non-food and feed products.

The study found different role of plants in molecular farming where Plants or plant cell cultures are used as bioreactors or cell factories to produce valuable proteins, Desired gene of our interest can be injected into plant nuclear or chloroplast genomes for transformation and Plant cells are able to produce recombinant proteins of interest at less cost than animal cell cultures.

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