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Biotechnological Interventions in Reducing Losses of Tropical Fruits

(*Prashant Barnwal, Dr. Shilpa Rana, Richa Sharma, Shivani Thakur, Sonu Dhakar and Yukta Jaswal)
Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, India
*Corresponding Author's email: prashant.barnawal456@gmail.com

Biotechnological interventions play a crucial role in reducing losses of tropical fruits, which are often susceptible to pests, diseases, and post-harvest deterioration. These interventions include genetic engineering, tissue culture, and bio preservation techniques that increases the resilience and shelf life of tropical fruit varieties. Genetic engineering allows for the development of disease-resistant fruit plants by introducing specific genes that confer resistance to pathogens. For example, transgenic papaya has been developed to resist the papaya ringspot virus, significantly reducing crop losses and ensuring a stable supply. Tissue culture techniques enable the propagation of disease-free plantlets, ensuring that farmers have access to healthy planting material. This method also allows for the rapid multiplication of high-yielding and superior quality fruit varieties, which can help meet market demands. Bio preservation methods make use of natural preservatives, such as beneficial microbes and plant extracts, to increase the shelf life of tropical fruits. These methods are environmentally friendly and decrease the reliance on synthetic chemicals, making them a sustainable option for fruit preservation. Overall, biotechnological interventions not only rise the productivity, quantity and quality of tropical fruits but also give to food security and the livelihoods of farmers in tropical regions.

Keywords: reducing losses, biotechnology, gene editing, transgenic, bioinformatics, antisense, omics

Introduction

Fruits predominantly grown in tropics, are considered as an necessary component of daily human diet all over the world. In the last few decades, the demand for tropical fruits has been increased significantly, particularly in the United States and European Union. Among several tropical fruits and banana, mango, citrus, papaya, pineapple, sweet potato, and cassava are the most major in international area. Tropical fruits are rich in health-benefiting compounds such as anthocyanins, flavonoids, carotenoids, vitamins, and Fibers, share an important source for human nutritional. The production of tropical fruits and vegetables is significantly affected by various factors, including abiotic and biotic stresses, for instance, in banana, drought stress causes up to 65% yield loss. Moreover, different diseases during plant growth and development limit fruit productivity. Most of the tropical fruits are perishable in nature, respire and transpire even after harvest, and are sensitive to chilling. This results in important postharvest losses, particularly in low- and middle-income countries, which are main helper of tropical produce. In some cases, this loss goes up to 50% of total produce, resulting in a major economic loss of such countries. Because of rising global demand of tropical fruits, their nutritional quality, and flavour, the need for developing technologies to maintain and increase the production of tropical crops and their pre- and postharvest quality attributes is necessary. In this review, we mainly focus on biotechnological approaches to reduce losses of tropical fruits and at pre- and postharvest levels.

Biotechnological Approaches

In resistance to temperate fruits, which includes apple, tomato, grapes, and so on, the genetic improvement of tropical fruits is limited possibly because of genome complexity, long juvenile phase, and lack of infrastructure and resources in developing countries.

Antisense and RNAi technology: Antisense and RNAi technology are gene silencing approaches that have been successfully used for developing tropical crops with improved fruit traits. One of the recent examples is development of banana with delayed ripening and extended shelf life through targeting two MADS box genes, *MaMADS1* and *MaMADS2*, which are essential for banana ripening. Recently, a genetically modified pineapple (*Ananas comosus*) with modified fruit color and delayed. Antisense technology involves the use of a strand of nucleic acid that is complementary to a specific mRNA molecule. The idea is that when the antisense strand binds to its target mRNA, it prevents the mRNA from being translated into protein. This can effectively "silence" the gene associated with that mRNA. Antisense oligonucleotides (ASOs) are often designed to bind to the mRNA and can be used in therapeutic applications to treat diseases caused by overexpression of certain genes.

Transgenic (heterologous and overexpression) approach: Transgenic approaches in fruits involve the introduction of foreign genes into the plant genome to express new traits. There are two main types of transgenic approaches: heterologous expression and overexpression. Heterologous expression refers to the introduction of a gene from one species into another. This is done to confer new traits that are not naturally present in the recipient species. For example, scientists might introduce a gene from a bacterium that provides resistance to a specific pest into a fruit plant. This can enhance the plant's ability to survive in challenging conditions and improve yield and quality. Overexpression, on the other hand, involves increasing the expression of a gene that is already present in the plant. This can be achieved by introducing additional copies of the gene or using strong promoters to drive its expression. Overexpressing certain genes can lead to desirable traits, such as improved nutritional content, enhanced flavor, or increased resistance to diseases. For instance, researchers might overexpress a gene involved in vitamin synthesis to create fruits with higher vitamin levels. The modern biotechnological tools permit the manipulation of genes from various sources and their insertion into plants to impart desirable traits for crop improvement. This approach has been applied for developing several tropical crops to prevent yield losses. Banana (*Musa* spp.) is one of the most significant economic commodities in tropical regions, having commercial production in over 130 countries. The banana industry is severely impacted by sigatoka leaf spot disease caused by a fungus.

Bioinformatics and omics interventions in tropical fruit biotechnology: Bioinformatics and omics interventions play a crucial role in tropical fruit biotechnology, enhancing the understanding and development of fruit crops through various high-throughput technologies.

Omics technologies, including genomics, transcriptomics, proteomics, and metabolomics, provide comprehensive insights into the biological processes of tropical fruits.

1. Genomics: This involves studying the complete genetic material of fruit crops, allowing scientists to identify genes responsible for important traits. For example, sequencing the genome of a tropical fruit can reveal genes related to stress tolerance or flavour.

2. Transcriptomics: This focuses on the RNA transcripts produced by the genome. By analysing the expression levels of different genes under various conditions, researchers can understand how tropical fruits respond to environmental stresses or developmental cues.

3. Proteomics: This examines the entire set of proteins produced in a fruit at a given time. Proteomic studies can help identify proteins that contribute to traits like disease resistance or fruit ripening.

4. Metabolomics: This involves the analysis of metabolites, the small molecules involved in metabolism. Understanding the metabolomic profile of tropical fruits can provide insights into their nutritional content, flavour, and aroma.

Another important technique is tissue culture, which enables the rapid propagation of disease-free plantlets. This method ensures that farmers have access to high-quality planting material, promoting better yields and healthier crops. It also allows for the preservation of valuable genetic traits in fruit varieties. Additionally, biopreservation methods, which utilize natural preservatives and beneficial microorganisms, can effectively extend the shelf life of tropical fruits. By reducing spoilage during storage and transportation, these methods help minimize post-harvest losses and enhance marketability.

Conclusion

The application of biotechnology in the cultivation and preservation of tropical fruits offers promising solutions to reduce losses, ensuring that these valuable crops can thrive in the face of various challenges. Biotechnological interventions have proven to be vital in addressing the challenges faced by tropical fruits, which are often vulnerable to various threats. Through genetic engineering, farmers can cultivate disease-resistant varieties, significantly minimizing crop losses. Tissue culture techniques ensure the availability of healthy planting materials, enhancing productivity and quality. Additionally, biopreservation methods provide sustainable ways to extend the shelf life of these fruits, reducing waste and improving marketability.

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