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Emergence of Nanotechnology: A Revolutionary Postharvest Management Strategies Ensuring Food Security

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SUMMARY

Nanotechnology has emerged as a promising solution to addressing the challenges in postharvest handling management by offering innovative solutions in preservation, packaging, and storage of crops, reducing food losses and enhancing food safety and security. Properties in nanotechnology include nanoclays, nanocomposites, metal nanoparticles, carbon nanotubes and graphene, liposomes and nanocapsules. The mechanisms of actions various from each. The detailing on how nanomaterials interact with food products and microorganisms. Nanocomposites contained silver nanoparticles, zinc oxide nanoparticles, or other antimicrobial agents to inhibit microbial growth on food surfaces. It has oxygen scavenging ability because it reaction with oxygen to reduce its concentration within the package, preventing oxidative degradation and inhibiting the growth of aerobic microorganisms while Ethylene Scavenging Packaging has nanomaterial-based ethylene absorbers to slow down the ripening process of fruits and vegetables. The potential of nanotechnology in the agricultural sector cannot be undermined because it reduces food losses at all levels.

INTRODUCTION

Globally, postharvest losses poses a significant threats to food handlers in meeting the food demand of a continuous increase population, contributing to food insecurity, farmers' economic downturn and unsustainable resource utilization. Noticeably, these losses usually occurred during and after harvesting and before consumer consumption. According to Wang *et al.*, (2021), insect infestations in grains makes it rapidly losses economic value and human unwillingness in consuming it, enhance it worth greatly diminished. Phyar *et al.*, (2014) affirmed that losses in food crops can be attributed to a complex interplay of varying factors, including improper storage methods and facilities, pest and insect attacks, microbial spoilage, enzymatic degradation, physical damage and transportation. Hence the need of postharvest handling management became a crucial aspect of the agricultural sector, as it significantly impacts the quality, safety, and shelf-life of various food crops. Over the years, food crops handlers have applied conventional or traditional approaches to postharvest handling, such as chemical treatments and controlled atmosphere storage, which have exhibited certain levels of limitations regarding it efficacy, non-eco friendliness in the case of pesticides which results to various health and environmental impacts. Hence, the high losses in food and consumer unacceptability of fit foods, necessitated the emergence of nanotechnology.

Identifiable causes of postharvest losses

A brief exploration of the various factors contributing to postharvest losses were highlighted and they include:

- Enzymatic degradation: Analyzing the activity of enzymes responsible for ripening, softening, and browning, leading to quality deterioration.
- Improper storage conditions: The structural patterns and position of storage houses highlight the significance of temperature, humidity, and atmospheric composition.
- Microbial spoilage: This focuses on the role and presence of bacteria, fungi, and yeasts in degrading fruits, vegetables, and grains.
- Physical damage: This addresses the impact of bruising, cuts, and abrasions during harvesting, handling and transportation, which create entry points for pathogens and accelerate spoilage.

Limitations of conventional postharvest technologies

A critical assessment of the limitations associated with conventional or traditional postharvest handling methods, such as:

- Chemical treatments: Concerns regarding pesticide residues, development of resistant pathogens, and potential health risks.
- Controlled atmosphere storage: High energy consumption, infrastructure costs, and suitability for specific commodities.
- Refrigeration: Energy intensity, infrastructure requirements, and uneven temperature distribution.
- Traditional packaging: Limited barrier properties, lack of real-time monitoring capabilities, and environmental concerns related to plastic waste.

The imperative need for innovative solutions emphasizing the requisite for novel, efficient, and sustainable approaches to address the complex challenges of postharvest handling and ensure global food security.

Revolutionizing Postharvest Management through Nanotechnologies

Nanotechnology is a rapidly evolving field manipulating matter at the atomic and molecular level, which offers a plethora of innovative solutions to revolutionize postharvest handling management, addressing the limitations of conventional methods and paving the way for enhanced food safety, extended shelf life of food crops, hence ensuring sustainable food security. Nanotechnology refers to the design, manipulation or influence, and utilization of materials, devices, or systems at the nanometer scale (1-100nm) as affirmed by (Pinkas et al., 2016). The emergence of this field has proven a significant positive impact on diverse industries at various levels and capacity, including health care, cosmetics, and largely agricultural sector across the world. Specifically, in the agricultural sector, nanotechnology has exhibited extensive potential in postharvest handling management, including the preservation, packaging, and storage of agricultural products, by addressing issues relating aflatoxin contamination enhance food safety and security concerns, the reduction in food waste, and enhancing the overall quality of crops (Sekhon, 2014).

This article maintains that nanotechnology, through its applications in packaging, sensing, delivery systems, and surface modification, provides a powerful and versatile system for significantly mitigating postharvest losses, leading to improved food availability, economic benefits, and environmental sustainability.

Principles and Applications of Nanotechnology to Postharvest Management

The fundamental overview of nanotechnology, explaining the unique components properties and materials that established it. Some of the key Nanomaterials for Postharvest include: Nanoclays, Nanocomposites, Metal Nanoparticles, Carbon Nanotubes and Graphene, Liposomes and Nanocapsules. The mechanisms of actions various each with it peculiar functions. The detailing on how nanomaterials interact with food products and microorganisms to achieve desired effects are contained here. The activities are antimicrobial packaging ability which made possible with nanocomposites containing silver nanoparticles, zinc oxide nanoparticles, or other antimicrobial agents to inhibit microbial growth on food surfaces. More so, oxygen scavenging ability because of the incorporation of nanomaterials that react with oxygen to reduce its concentration within the package, preventing oxidative degradation and inhibiting the growth of aerobic microorganisms while Ethylene Scavenging Packaging is the development of nanomaterial-based ethylene absorbers to slow down the ripening process of fruits and vegetables. All these is to achieve food gain at all levels.

Considerations to usage of Nanotechnology in Postharvest Management

Despite its importance and benefit in the agricultural sector, there are some holdup to it actual scaling ranging from perceived toxicity and environmental impact of nanomaterials, regulation and standardization of nanotechnology in food applications, cost-effectiveness and scalability of nanotechnology-Based Solutions, consumer perception and acceptance of nanotechnology in food. Although, Rikta and Rajiv, (2021) affirmed that nanotechnology have the capacity to solve the shortcomings of conventional pesticides in food.

Future directions and opportunities for nanotechnology in postharvest management

The future still holds a lot in nanotechnology as the development of sustainable and biodegradable nanomaterials, integration of nanotechnology with precision agriculture and big data, development of Personalized postharvest technologies and increased collaboration and knowledge Sharing. Emphasizing the importance of fostering collaboration between researchers, industry stakeholders, and policymakers to accelerate the development and implementation of nanotechnology-based solutions for postharvest management.

CONCLUSION

Nanotechnology holds immense promise for revolutionizing postharvest handling management, offering a diverse array of innovative solutions to mitigate spoilage, extend shelf life, enhance food safety, and improve overall efficiency. From advanced packaging materials with antimicrobial and sensing capabilities to targeted delivery systems for postharvest treatments and surface modification techniques for enhanced sanitation, nanotechnology provides a powerful mechanism for addressing the complex challenges of postharvest losses while challenges related to toxicity, regulation, cost-effectiveness, and consumer perception need to be carefully addressed, the potential benefits of nanotechnology for ensuring global food security and promoting sustainable agriculture are undeniable. Therefore, it recommended that food handlers should embrace the emergence of nanotechnology as a core component of curbing and preventing postharvest losses. It is crucial for achieving sustainable food security and mitigating the devastating consequences of food losses in a world faced with increasing population and climate change

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