# Chapter 21
# Active Antimicrobial Packaging Innovations: Safeguarding Food Quality and Consumer Health

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## ABSTRACT

*Active antimicrobial food packaging has emerged as a promising solution to address the growing challenges associated with food safety and shelf-life extension. This innovative packaging technology incorporates antimicrobial agents directly into packaging materials to actively inhibit the growth of microorganisms, thereby preventing spoilage and enhancing the safety of perishable food products. This chapter provides a comprehensive overview of the key concepts, advancements, and applications of active antimicrobial food packaging. The review begins by exploring*

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*the fundamental principles behind active antimicrobial packaging, elucidating the various antimicrobial agents such as essential oils, antimicrobial peptides, and nanoparticles. It discusses the mechanisms by which these agents exert their antimicrobial effects, including the disruption of cell membranes, inhibition of enzymatic activities, and interference with cellular processes. Food packaging applications across different food categories, including fresh produce, meat, dairy, and bakery products are also highlighted.*

## INTRODUCTION

Storage, sale, distribution and transportation of the material and goods can be made easy by the application of good packaging. Packaging of material calls for good knowledge of material properties as well as the environment to which this material is exposed. Packaging includes designing, evaluating and fabricating the packaging. The field of packaging is evolving due to the need for sustainable, biodegradable and environment-friendly packaging. The food packaging is a rapidly evolving field with novel materials and technology replacing the conventional methods. With the evolving methods in food technology and new food processing methods and their requirements, food packaging technology is taking center stage in the food and agricultural sector. The storage of the seeds and the processed food has huge potential. The processing of fruits, milk products, and vegetables is focused on reducing volume and increasing the durability of the goods. The easy and affordable transportation of the material is also a very important aspect. The microbial contaminants on food products deteriorate food quality and reduce market value. Antimicrobial properties of some compounds like zinc oxide and chitosan can be useful for packaging purposes.

Various nanomaterials are being explored for the packaging. Silver nanoparticles have excellent antimicrobial properties and, hence, can be used for packaging. Magnetic nanoparticles are used to bond the pathogens in food samples for quality checking. Smart packaging is a rapidly evolving concept that enables the monitoring of the packaging and its surrounding environment. The food packaging business is growing rapidly in India, and it was worth approximately 32 billion USD in 2022. By 2029, it is expected to reach 86 billion USD (BlueWeave Consulting, 2023). In this period, this industry is expected to grow at 14.8%. Various players in the food delivery market are potentially the largest customers of the packaging industry.

The packaging can be primary, secondary, tertiary and ancillary packaging. Primary packaging is important as it is for medicines, beverages, and other perishable items. This packaging needs a proper selection of packaging materials. The material should not be toxic or reactive. Also, it needs to resist possible microbial contami-