

The Role of Smart Packaging in Improving The Quality and Safety of Bakery Products

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Article Info	ABSTRACT
Keywords: Smart packaging, Product quality, Food safety, Bakery Packaging innova-tion	The development of packaging technology presents smart packaging innovations that can improve the quality and safety of bakery products. Smart packaging consists of intelligent packaging and active packaging, which can provide real-time information about product conditions and extend shelf life through active interaction with the environment. This article discusses the concept, benefits, and implementation of smart packaging in the bakery industry, highlighting aspects of food safety, product durability, and consumer preferences for this packaging technology. It also reviews the trends and challenges in implementing smart packaging as an innovative solution for the quality-oriented and sustainable bakery industry.
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INTRODUCTION

The bakery industry is growing rapidly along with the increasing demand for quality and durable food products. One of the main challenges in this industry is maintaining product quality and safety during distribution and storage. Smart packaging comes as an innovative solution that is able to provide additional protection as well as real-time information about the condition of the product. This article aims to explore how smart packaging can contribute to improving the quality and safety of bakery products.

Smart packaging is an innovative solution that not only serves as a product protector but also provides real-time information about the condition of the product and extends its shelf life. Smart packaging consists of intelligent packaging and active packaging, each of which has an important role in ensuring that bakery products remain in optimal condition. With features such as intelligent packaging that is able to detect environmental changes and active packaging that interacts with products to maintain their freshness, this technology is increasingly attracting the attention of the food industry. Intelligent packaging allows monitoring of product conditions through sensors or indicators, while active packaging is able to actively control the environment in the package, such as reducing oxygen or maintaining humidity. With the combination of these technologies, the bakery industry can improve efficiency in supply chain management and provide added value to consumers through more transparent and accurate information about the condition of the products they consume. This article aims to explore how smart packaging can contribute to improving the quality and

safety of bakery products and review the challenges and prospects for its application in the future.

METHODS

This research uses a qualitative descriptive approach with a literature study method. Data sources were obtained from scientific journals, research articles, and industry reports that discuss smart packaging innovation in the bakery industry. The analysis was carried out by examining various concepts, implementations, and challenges faced in the application of smart packaging. The data collected was analyzed using content analysis techniques to identify the latest trends and developments in this field.

RESULTS AND DISCUSSION

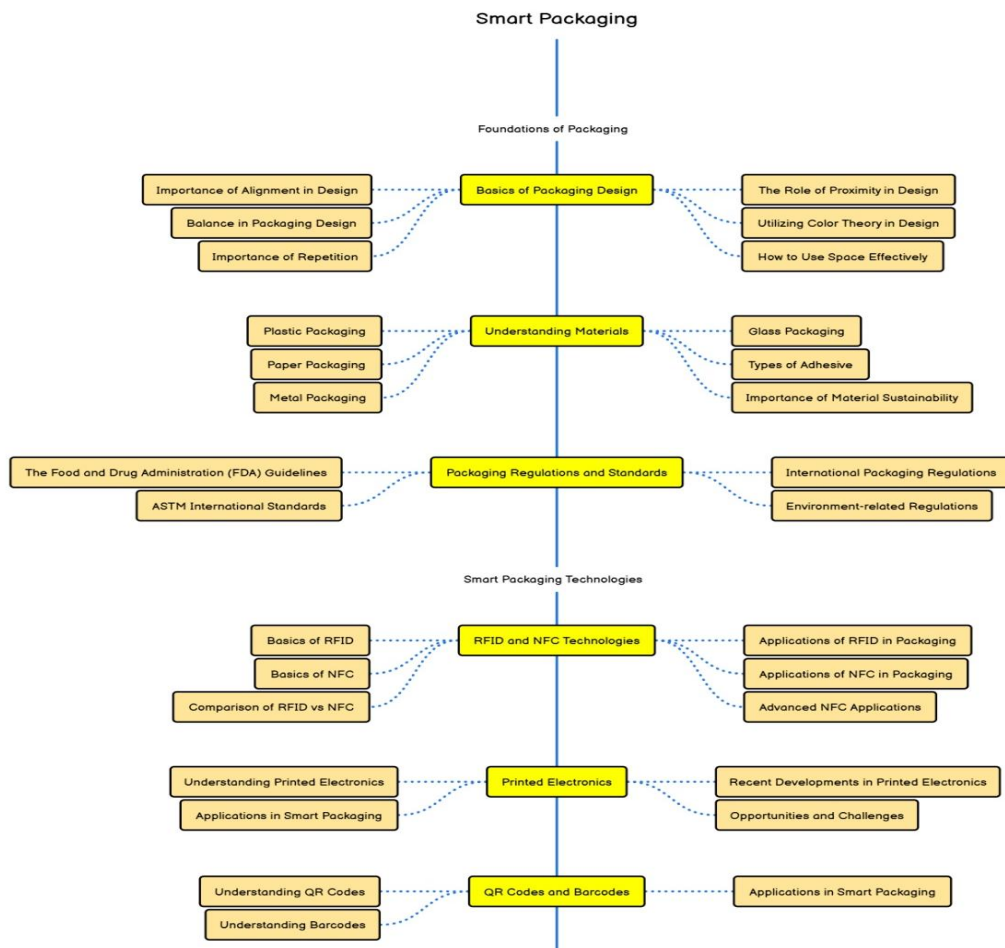


Figure 1. Smart Packaging

Smart Packaging Concept

Smart packaging refers to packaging that not only protects the product but also interacts with it to improve durability and safety. Smart packaging is divided into two main categories:

- a. Active Packaging: Packaging that actively plays a role in extending product shelf life by absorbing oxygen, regulating moisture, or releasing antimicrobial agents.
- b. Intelligent Packaging: Packaging that is able to provide information regarding the condition of the product through sensors or indicators that detect changes in temperature, humidity, or the presence of microorganisms.

Benefits of Smart Packaging in the Bakery Industry

- a. Improved Food Safety: In-pack sensors can detect microbial contamination, temperature changes, or gases that signal product spoilage.
- b. Extends Shelf Life: Active packaging technology helps control the environment inside the package to keep products fresh for longer.
- c. Transparency and Information for Consumers: Intelligent packaging allows consumers to know the condition of the product in real-time through visual indicators or digital applications.
- d. Efficiency in Distribution and Storage: Monitoring the condition of products in the distribution chain can reduce the risk of waste due to products that are no longer fit for consumption.

Implementation of Smart Packaging in Bakery Products

Some of the technologies that have been applied in smart packaging for bakery products include:

- a. Oxygen Scavengers: Oxygen scavengers in packaging to reduce oxidation that can lead to mold growth.
- b. Humidity Control Films: Moisture control membranes that help keep the texture of bakery products crisp.
- c. Time-Temperature Indicators (TTI): Time-temperature indicators that help detect whether products have been subjected to high temperature exposure during distribution.
- d. RFID and QR Code Labels: Tracking technologies that allow manufacturers and consumers to monitor product information through digital devices.

Challenges and Prospects of Smart Packaging in the Industry

Although smart packaging offers various benefits, its implementation still faces several challenges, including:

- a. High Production Costs: Sensor technology and specialized materials in smart packaging are still relatively expensive for mass production.
- b. Consumer and Producer Education: Awareness of the benefits and how to use smart packaging still needs to be raised.
- c. Sustainability and Recycling: The development of environmentally friendly materials that can be decomposed easily is a challenge in implementing smart packaging.

However, the prospects for the application of smart packaging in the future are quite bright, especially with the increasing awareness of food safety and sustainability. innovations in packaging materials and integration with digital technology are expected to further drive the adoption of smart packaging in the bakery industry.

CONCLUSION

Smart packaging offers innovative solutions in maintaining the quality and safety of bakery products. With active and intelligent packaging features, this technology is able to extend shelf life, improve food safety, and provide added value for consumers and producers. Although it still faces some challenges in production costs and market education, smart packaging has great potential in supporting a more sustainable and technology-based bakery industry.

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