

## Smart Packaging: Concept, significance and opportunities

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### Introduction

The term "smart packaging" describes how different technologies are incorporated into packaging to improve its capabilities beyond simple confinement and protection. These technologies, which enable features like shelf-life extension, freshness monitoring, and enhanced consumer communication, can include sensors, RFID tags, NFC, and QR codes. Active and intelligent packaging are two major categories for smart packaging.

While intelligent packaging keeps track of the food's condition and conveys this information, active packaging works with the food itself to prolong shelf life. Oxygen absorbers, CO<sub>2</sub> scavengers, and antibacterial agents are examples of components that can be included in active packaging. Food degradation or spoiling may be indicated by changes in temperature, humidity, or the presence of particular gases, all of which can be detected by sensors in intelligent packaging. (Schaefer *et al.* 2018)

### Benefits of Smart Packaging

**Improved product quality and safety:** In addition to lowering the chance of food spoiling, smart packaging can help preserve or increase food's shelf life.

**Better customer communication:** In order to help consumers make educated decisions, smart packaging may notify them about the safety, quality, and freshness of products.

**Decreased food waste:** Smart packaging can help cut down on food waste by keeping an eye on food condition and extending shelf life.

**Better supply chain management:** It is made possible by smart packaging, which can offer information about the state of food throughout storage and transit.

**New business prospects:** Customised package solutions, data-driven insights, and value-added services are just a few of the opportunities that smart packaging may present to companies (Shukla *et al.* 2024)

### Applications of Smart Packaging Examples

**Food packaging:** QR codes can give access to product information, time-temperature indications can keep an eye on the cold chain, and sensors can identify spoiling.

**Pharmaceutical packaging:** In addition to monitoring temperature during transportation and offering advice on appropriate storage, smart packaging can assist guarantee the integrity of pharmaceuticals.

**Consumer electronics:** Digital content access, product tracking, and authenticity verification are all made possible by smart packaging.

**Logistics and transportation:** Real-time location data, cargo tracking, and condition monitoring throughout transit are all possible with smart packaging.

(Stevens, 2025)

### Smart packaging's drawbacks

**High cost:** The cost of smart packaging technologies may be higher than that of conventional packaging, which could affect affordability.

**Complexity:** Creating and putting into practice smart packaging solutions can be challenging, requiring specific skills and experience.

**Sustainability issues:** The effects on the environment may be a worry with some smart packaging materials and technologies.

**Acceptance by consumers:** If consumers find new technologies intimidating or believe they are overly complicated, they may be reluctant to embrace smart packaging (Vasuki *et al.* 2023).

### Trends for the Future:

**Integration of AI and IoT:** To facilitate more advanced monitoring and communication, smart packaging is probably going to see a greater degree of integration with AI and IoT technology.

**Development of sustainable and biodegradable materials:** In order to address environmental issues, it will become more and more crucial to adopt sustainable and biodegradable materials.

**Customised packaging options:** Smart packaging will make it possible to create customised package options that are suited to the requirements of certain customers.

**Improved product traceability and authentication:** Smart packaging will be crucial in enhancing product traceability and authentication, which will aid in the fight against fraud and counterfeiting. (Shukla *et al.* 2024).

## Conclusion

In certain ways, smart packaging will completely change the future of retail and the goods we buy as customers. In Japan, a number of businesses have established smart packaging departments. Nevertheless, there are numerous obstacles to the widespread adoption of sophisticated technologies—specifically, their high price, hesitant consumer acceptance, fostering harmonious collaboration among supply chain partners, and a few intricate legal and regulation challenges. Can packaging materials and structures be genuinely active-sensing and reacting in a good way while remaining innocuous to other properties? This is another frequently asked question in relation to this. The field of active packaging is still in its infancy. Presenting the materials to packaging specialists so they may give their future visions shape is a problem for plastic scientists and technicians. However, compared to other packaging materials,

plastics have so far been able to provide more "Smart Packaging" options.

## References

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