Popular Article

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Smart Packaging Technology for Meat Products "The Features of Freshness"

B.P. Mishra*, S. G. Sahoo, P.K.Rath, I. Bisoi, S. Sahu
College of Veterinary Science and Animal Husbandry, Odisha University of Agriculture and Technology (OUAT), Bhubaneswar-751003, Odisha
*bidyutpravam@ouat.ac.in
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★ Key message

- Smart packaging technologies, including active, intelligent, bio-based, RFID-based, and sensor-based systems, provide real-time monitoring of meat freshness, safety, and quality, helping to reduce spoilage, extend shelf life, and improve consumer confidence.
- By integrating freshness indicators, sensors, and traceability tools, smart packaging supports safer, more sustainable meat preservation and supply chain management, although challenges such as high cost, technical complexity, and limited consumer awareness remain.

Abstract

Gradual increase in meat production as well as consumer preferences for meat products compels the veterinarians as well as animal scientists to think of ready to cook or ready to eat meat products. Ever increasing purchasing capability of modern-day individuals with changing life style scenario, one is more interested in quality foods with ready-made information labeled on the purchased products. It is the need of the hour for assessing the real time freshness indicators of meat products for which smart packaging is the solution which not only gives the real-time data but also gives a detail information on various quality parameters from farm to table as the preferred choice of modern-day smart consumers.

Introduction

Meat and meat products consumed because they have protein, vitamins and minerals that are necessary for our health. Meat is one of the foods that goes bad quickly. This is because meat has a lot of water and nutrients in it which's a great place, for tiny living things to grow. When meat goes bad it is usually because of these living things or because of the way the meat changes over time or because of chemical reactions. This makes the meat smell bad change color and not be good to eat. The usual way of packaging meat just helps to protect it from getting damaged or touched by things that could make it go bad. This kind of packaging does

not tell us if the meat inside is really fresh and safe. Usually, people look at the expiry date. How the meat looks to see if it is good. Smart packaging technology is the need of the hour for ensuring the real time quality of the meat as per the smart consumer's preferred choice.

Types of Smart Packaging

1. **Active packaging**

This is one of the advanced packaging systems which interfere in various controlling factors like moisture, microbial growths as well as oxygen availability that will be helpful in extending meat shelf life, ensuring optimum quality with improvements in safety parameters.

Types of Active Packaging Used for Meat

a) Oxygen Scavenger
b) Carbon Dioxide (CO_2) Emitters and Absorber.
c) Antimicrobial Packaging
d) Moisture Absorber
e) Antioxidant-Releasing Packaging

Advantages of Active Packaging in Meat	*Limitations*
• Extending shelf life significantly. • Maintaining color, flavor, and texture. • Reducing microbial spoilage and food-borne risks. • Minimizing use of chemical preservatives in meat. • Improving consumer confidence and product quality.	• Higher cost compared to conventional packaging. • Regulatory approval required for active agents. • Consumer awareness and acceptance may be limited. • Proper disposal and environmental impact must be considered.

2. **Vaccum packaging**

In this packaging system, fresh meat is kept in a specially designed tightly sealed plastic pouch after removal of air inside using a vacuum sealing machine which is helpful in reducing microbial growth, more particularly aerobic bacteria, thus delaying oxidative damage to the meat without altering meat colour and flavor. In most instances, there is slight less consumer preference owing to slightly darker colour of meat attributed to reduced oxygen in vacuum packaging system.

3. Intelligent packaging

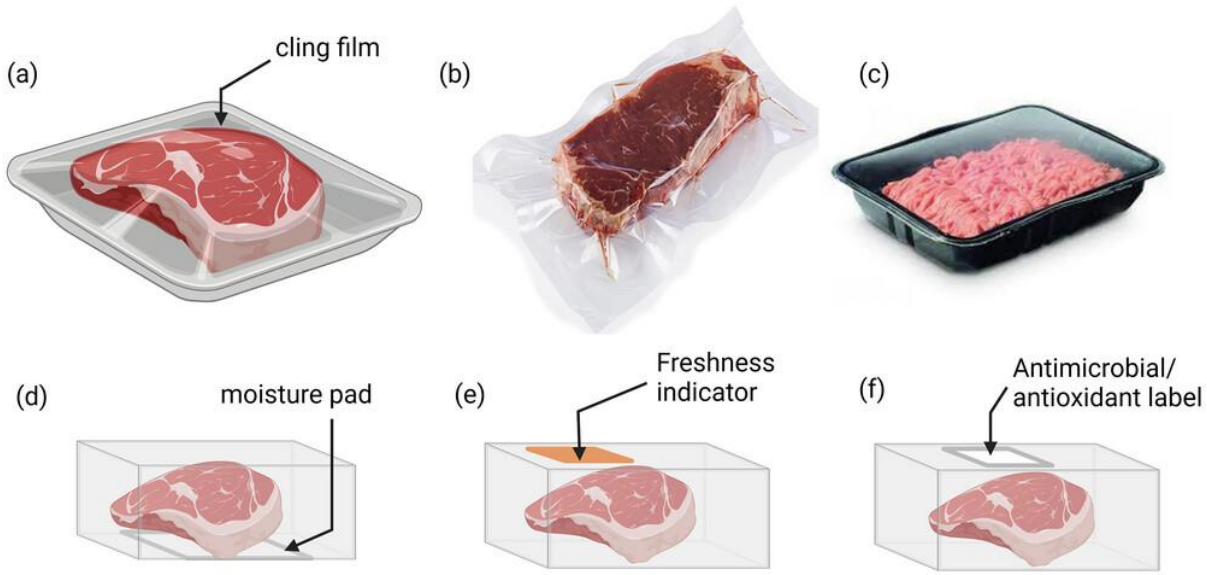
It is a special meat packaging system giving information related to meat freshness indicators like pH, real time temperature as well as gas indicators from storage to marketing even during transportation also. Recent developments like provision of implementing barcode and RFID system now enhancing the intelligent packaging system for real time product identification and monitoring during its supply chain.

4. Bio-based Smart packaging

It refers to packaging systems that ensures use of biodegradable as well as renewable resources like plant-based polymers which when combined with smart features like real time freshness indicators and sensors, that create an eco-friendly packaging system. Many environmentally friendly alternatives like starch, chitosan, petroleum-based plastics etc may be considered for use of Bio-based smart packaging.

Role of smart functions in meat packaging

Chitosan based biodegradable films considered relatively strong. You can see through it. People often mix these materials with colorings or special helpers like enzymes or biosensors. This helps make the packaging even smarter. Bio-based smart packaging uses these materials to make something really useful. The materials like chitosan and PLA are very important, for bio-based packaging.



Benefits of Bio-Based Smart packaging

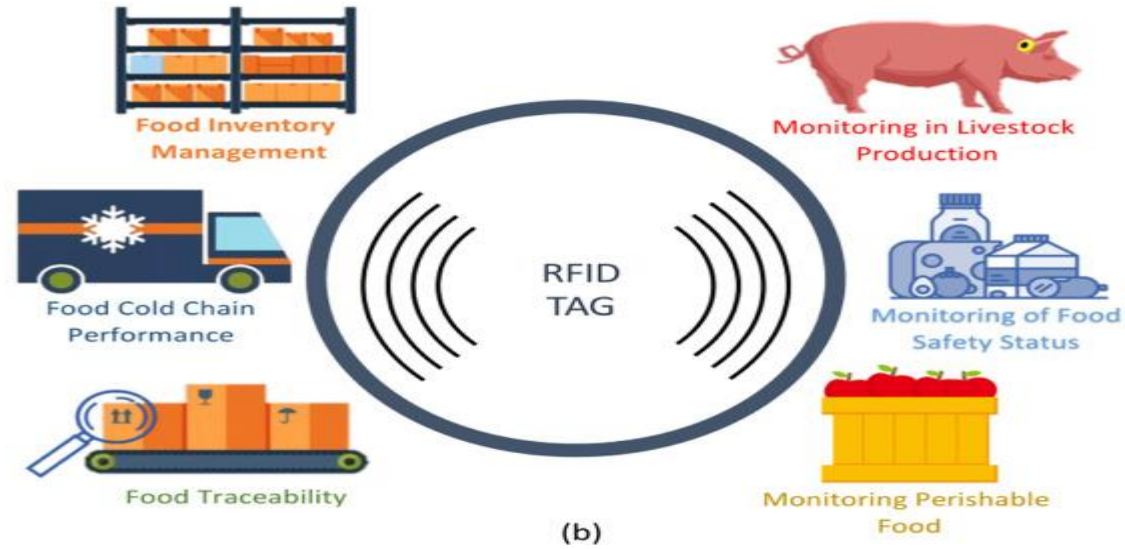
Bio-based smart packaging is really useful for keeping an eye on things without messing with the product itself. We have these freshness indicators that are made from stuff like the color from red cabbage, berries or flowers. when gases like ammonia and hydrogen

sulfide, which are produced when something goes bad,comes into contact with indicator the indicator changes the colour.This way people can see if the meat is fresh or not. We also have these time-temperature indicators made from bio-polymers that tell us if the product got too hot or cold during shipping and storing. Bio-based smart packaging is really good, at helping us figure out if the product is still good to use.

5. RFID-Based Smart Packaging

It has electronic tags that are attached to or put inside the package. Each RFID tag has a computer chip and an antenna. By using waves these RFID tags talk to RFID readers so they do not need to touch the reader or be in its line of sight like those barcode things. RFID based smart packaging can track the temperature as well as gives a lot of detail information about the packaged meat comprising its processing date, shipment date, batch number as well as real-time freshness indicators.

(a)



(b)

6. Sensor-Based Smart Packaging

It helps in assessing the quality and freshness of meat and meat products through certain sensors. Any deterioration in meat quality may quickly be evaluated through bad smells as well as accumulated gases like ammonia, carbon dioxide and hydrogen sulfides which traced by the attached sensor in smart packaging system. Sensor-based packaging sensors give us a signal

when this happens, like a color change or a light that we can see. This helps us know if the meat is still good to eat or not. It is a way to keep track of the quality of meat and meat products.

Advantages of Smart Packaging

It is good for the environment. Helps to keep food fresh and safe for long time. This builds trust with shoppers. Helps to reduce food waste. By the use of indicators it shows if food is fresh or not. Consumers like this because it is more natural and safer.

Limitations

It is really expensive. This makes the price of meat products go up. It is very complected from technical point of view.

Conclusion

The use of packaging makes food safer reduces spoilage and waste keeps food fresh for longer and makes consumers feel more confident. It gives information about how fresh meat is, which helps retailers and consumers make safe choices. However, some challenges still need to be solved like the cost, technical difficulties being sensitive to the environment and not many consumers being aware of it. Overall smart packaging is a solution for preserving meat. Smart packaging helps to keep meat fresh. It will likely become more important for food packaging in the future. Smart packaging is efficient and sustainable, for meat.

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