Research Article

ACS Publisher
www.acspublisher.com

Journal of Meat Science

Year 2023 (June), Volume-18, Issue-1

ISSN 0975-5209 (Print)
ISSN 2581-6616 (Online)

Advances in Intelligent Food Packaging of Meat

Priya B. Koneti, M. Raziuddin* and A. A. Devangare

Department of Livestock Products Technology, College of Veterinary and Animal Sciences, MAFSU, Udgir-431402 (M.S) India.

ARTICLE INFO

• *Corresponding author.
• *E-mail address:* dr_razi@rediffmail.com (M. Raziuddin)

Received 17-07-2023; Accepted 29-09-2023

DOI: 10.48165/jms.2023.180104

ABSTRACT

Numerous innovative food packaging options are available on the market that let consumers monitor the product quality, safety, integrity, cleanliness, freshness, and purity before consumption. It is also critical to minimise food fraud, spoilage, contamination, and ineffective food safety communication. To satisfy this need, a number of packaging technologies, including intelligent packaging and active packaging have been developed. In this article, a variety of intelligent packaging systems, including data carriers, indications, and sensors is reviewed. By sending out signal like a change in colour, indicators provide internal visual that reveal the state of food. With the aid of transducers, digital sensors are able to recognise changes in the product.

Keywords: Meat packaging; Intelligent packaging; Sensors; Radio frequency identification; Smart packaging; quality.

INTRODUCTION

One of the key procedures for maintaining the quality of meat during transportation, storage, and usage is packaging. Distribution and marketing become more effective and quality decline is slowed. Protection, communication, convenience and confinement are the four fundamental purposes of packaging (Han, 2005).In conventional packaging, the package acts as a marketing tool to engage with customers, protect the meat product from the harmful effects of the environment, hold objects of all sizes and shapes and make it simpler and more convenient for the consumer to use the product. Because of how complicated today's world has conventional packaging is no longer sufficient to maintain the quality of meat. Packaging protects the meat against microbial, chemical, airborne and light degradation. How a package is utilised has a big impact on how long it will last. Normally, this function is passive and inert, but in recent years, Intelligent and Active packaging have drawn more attention and various commercial products have been developed and used in the meat packaging. By minimising the migration of chemicals into the meat from the packaging materials and the impact of the package on the sensory aspects of the meat, the basic standards are often focused on safety for packaging materials that come into contact with meat. Intelligent packaging has opened up new possibilities for packaging of meat, such as the idea of substances like antioxidants and preservatives purposefully migrating from the box into the meat. The concept of intelligent packaging, which is still in its early stages of development, aims to improve food safety and quality by using the communication capabilities of the package to help in decision-making. Although the definitions of these phrases are sometimes used interchangeably, they typically have different meanings. Additionally, packaging is a tool for optimisation that facilitates the acquisition of the necessary quantity of produce and in turn, indirectly contributes to waste minimization (Biji *et al.*,2015).At the corporate level, routine tests and periodic

microbiological and chemical studies are typically used to evaluate the quality of meat (Viswanathan, & Radecki, 2008).Due to rising demand for intelligent innovations, which are expected to dominate changes in meat packaging in the upcoming years (Vanderroost *et al.,* 2014).

Definitions

Smart packaging is a term used to describe a product that combines the characteristics of both intelligent and active packaging. Intelligent packaging is a term used to describe a packaging system that senses and communicates. Monitoring packaged meat conditions to provide information about the meat quality during storage and transportation is another definition of intelligent packaging. A packaging system that is capable of performing intelligent tasks (such as sensing, detecting, tracing, recording, and communicating) to aid in decision-making to increase shelf life, improve quality, increase safety, provide information, and alert users to potential issues is referred to as intelligent packaging. If a package can track the items, recognise its surroundings within or outside the container, and interact with humans, it might be considered intelligent. For instance, an intelligent package can track the safety and quality status of a meat and give the consumer or food manufacturer an early warning. One example of intelligent packaging is a strategy that includes an external or internal indication of the active product's quality and history. Particularly, improvements in biosensors and biotechnology used in meat packaging systems are anticipated (Han, 2005).

A related phrase is "smart packaging" which makes use of smart technologies and information carriers like barcodes and RFID tags to provide consumers with comprehensive product information (Hoganand Kerry 2008).The term "intelligent packaging" was coined by (Jang and Won in 2014) and is described as "the packaging system that detects, communicates and monitors the circumstances of packed food to deliver information on food quality, safety and the history of a product during transit and storage." This shows how intelligent packaging may perform the six roles of monitoring, sensing, detecting, tracking, recording and communicating. Aspects of safety worries connected to Active and Intelligent packaging were outlined by the European Food Safety Agency (EFSA) (Restuccia *et al.,* 2010). In a fascinating study, a bromothymol blue-tetra butylammonium ion pair dye was used as a CO_2 sensor in multi-layered kimchi packets to prevent colour from migrating into meals with high water content. Additionally, by implementing nano barcode technology, batch information may be encrypted into packaging materials and enabling batch owners to monitor the supply chain without having to disclose corporate information to distributors (Neethirajan, and Jayas, 2011; Smolander, & Chaudhry, 2010).

Applications of Intelligent Packaging (Kalpana *et al.,* 2019)

1. Quality and safety indicators
   - Time-temperature indicators (TTIs)
   - Microbial growth
   - Gas sensing devices
   - Pathogen detection
2. Traceability devices
   - Radio frequency identification (RFID) chips/tags
3. Product authenticity
   - Hidden design print elements-RFID

Intelligent Packaging Systems

Indicators based packaging system

Indicators are devices that give some information about the presence or absence of a substance or the degree of interaction between two substances by changing in characteristics, like colour (Kuswandi *et al.,* 2011). A customer can receive information on microbial activity, food quality and/or other characteristics from an indicator. It functions based on specific factors such as the absence or presence of a target chemical or biological substance, the intensity of the reaction(s) between two or more substances or the difference in chemical concentrations present in food as indicated by an irreversible and obvious colour change or movement of colour frontiers. In their broadest terms, indicators can be divided into internal and external categories. According to (Pavelkova, 2013), the former contains indications that are typically put outside the box while the latter includes indicators that are really present inside the container.

Temperature Indicators

This thermometer provides data on the temperature and displays past and present temperature variations. In storage or shipping, it serves as an addition to labelling if there is perishable meat. When meat kept in storage above the recommended temperature, microorganisms quickly multiply (Welt *et al.,* 2003). The package surface is intended to combine the package's cumulative time-temperature history. Consequently, it provides hazy information about the product along the entire distribution chain. The time-temperature history is represented visually as a colour movement or colour shift. Commercially accessible time temperature indicators rely on a variety of reaction mechanisms (diffusion, polymerization or enzyme reaction). The reaction kinetics of the temperature-dependent indicator

and activation of the indicator at the moment of packaging is a common feature for all concepts.

Time Temperature Indicators (TTIs)

The time-temperature history is represented visually as colour movement or colour shift. Commercially accessible time temperature indicators rely on a variety of reaction mechanisms (diffusion, polymerization, or enzyme reaction). The reaction kinetics of the temperature-dependent indicator and activation of the indicator at the moment of packaging is a common feature for all concepts. Because of their straight forward functionality, TTIs are regarded as being user-friendly and accessible technology (Taoukis, 2001). The Fresh-Check from Life line Technologies is a TTI indicator. Its function is based on a polymerization process resulting in a colour shift in the indication range. A fresh TTI has a clear centre. The product has to be consumed right away if the colour of the active centre and the outside ring match. TTIs from expired goods have a dark centre.

TTIs may be classified into two categories (Taoukis and Labuza, 2003)

a. Critical temperature indicators (CTI) demonstrate the product's exposure to a certain component at a temperature above (or below) a reference point. Other significant situations where a CTI might be helpful include the denaturation of a crucial protein over the critical temperature or the development of a harmful microbe.

b. Critical time temperature integrators (CTTIs) are helpful in identifying distribution-chain breakdowns and for items where reactions that are vital to quality or safety are started or occur at measurable rates above a critical temperature. Enzymatic activity that is hindered below the critical temperature and microbial growth are two examples of these processes.

Gas indicators

Gas indicators can track changes in gas composition inside the package and so assist in keeping an eye on the product's safety and quality. Gas indicators can take the shape of labels or be printed on packing materials (Yam *et al.,* 2005). The composition of the gas in food packaging can alter as a result of the gas generated by lipid oxidation and microbial deterioration (Mohebi and Marquez, 2015). These indicators change their colour by either a chemical or enzymatic reaction, typically providing information about the presence or absence of oxygen or carbon dioxide (Jong *et al.,* 2005). The development of oxygen and carbon dioxide indicators has received a lot of attention in recent years due to the significance of these gases in culinary applications (Roberts *et al.,* 2011; Jung *et al.,* 2012; Lee & Ko, 2014; Vu & Won, 2014).

For optical oxygen sensing, a variety of devices and materials have been reported recently (Papkovsky *et al.*1995; Thompson and Lakowicz, 1993; Trettnak *et al.,* 1995). These sensors are typically made of solid-state materials and work by quenching luminescence or changing absorbance in response to physical contact with the analyte.

Oxygen indicators

This indicator provides data about leakage. This indication is used for meat packaging that is stored in a controlled or modified environment. In contrast to systems based on absorption or reflectance, oxygen sensors are based on luminescence detection and constitute an alternate method to solely visual oxygen indicators. They offer improved sensitivity and accuracy of the quantitative readings. An alkaline substance like sodium hydroxide, a redox dye like methylene blue, and a reducing substance like reducing sugars make up a standard oxygen indicator. Recently, oxygen indicators based on oxidative enzymes have been developed. The indication also includes other ingredients like a solvent (water or alcohol) and a bulking agent (such as silica gel, polymers, cellulose materials or zeolite) (Mills, 2009).The indication can be made as a tablet, label, printed layer or laminated in a polymer film (Banerjee *et al.,* 2016).

Carbon dioxide indicators

This indicator provides data on the carbon dioxide content of the packaging. In order to determine the level of fermentation in meat products, a carbon dioxide indicator system using chemical dyes (bromocresol purple or methyl red) incorporated into polymeric sheets is used. These indicators provide details on the carbon dioxide content of packages during supply and storage but also detect the early spoilage of the food. As the concentration of CO_2 changes it alters the pH, which consequently changes the colour of the indicator (Hong and Park, 2000; Neethirajan *et al.,* 2009).

Freshness indicator

Intelligent packaging systems can give either direct or indirect information on the quality of meat products (for example, changes in packaging oxygen concentration

may suggest quality decline through proven correlation). Indicators of product quality that are directly related to chemical changes (Nychas *et al.,*1998) or microbial growth within a food product are called freshness indicators. Through interactions between the package's indicators and microbial growth metabolites, microbiological quality may be assessed (Smolander, 2003). There are relatively few viable intelligent package indicators for freshness identification currently available. Despite this, there is a lot of potential for the creation of freshness indicators based on the known metabolites that indicate quality. The majority of freshness indicators are based on indicator colour changes in reaction to microbial metabolites generated during spoiling (Smolander, 2003) and there are many distinct types of them. Before substantial commercial acceptance is feasible, a number of drawbacks to freshness indicators based on broad-spectrum colour variations need to be addressed. Because there is a lack of specificity, colour changes that indicate contamination can occur in items without any appreciable sensory or microbiological quality degradation. The presence of certain target metabolites does not always imply poor quality. The relationships between target metabolites, product type, and organoleptic quality and safety appear to require more precise correlations. When using indicators, manufacturers may be discouraged by the possibility of false-negative results unless clear evidence of true decomposition can be guaranteed. However, intelligent materials may need a demonstration of the reliability of the information provided, especially to avoid misleading the consumer (Rijk, 2008).

CONCLUSION

The future of meat packaging lies on intelligent packaging that is able to do more than merely hold and safeguard its contents like colour, flavour and texture attributes. This type of packaging attracts the consumers and make them to believe in safety assurances. Intelligent packages are communicative packaging that resolutely fill the market application gap when it comes to the evaluation of various food items, including liquid foods, meat, fish, dairy, fruits, and vegetables.

REFERENCES

Banerjee S, Kelly C, Kerry JP, Papkovsky DB (2016) High throughput non-destructive assessment of quality and safety of packaged food products using phosphorescent oxygen sensors. Trends in Food Science & Technology50:85-102.

Biji KB, Ravishankar CN, Venkateswarlu R, Mohan CO, Gopal TS (2016)Biogenic amines in seafood. Journal of food science and technology 53 :2210-2218.

De Jong AR, Boumans H, Slaghek T, Van Veen J, Rijk R,Van Zandvoort M (2005) Active and intelligent packaging for food. Food additives and contaminants 22(10):975-979

Han JH, Ho CH, Rodrigues ET(2005) Intelligent packaging. Innovations in food packaging138- 155

Hogan SA, Kerry JP (2008)Smart packaging of meat and poultry products. Smart packaging technologies for fast moving consumer goods 33-54.

Jung J, Puligundla P, KoS(2012)Proof of concept study of chitosan-based carbondioxide indicator for food packaging applications. Food Chemistry135:2170-2174.

Kalpana S, Priyadarshini SR, Leena MM, Moses JA, Anandharama Krishnan C (2019) Intelligent packaging: Trends and applications in food systems. Trends in Food Science and Technology93:145-157.

Kuswandi B ,Murdyaningsih EA (2017) Simple on package indicator label for monitoring of grape ripening process using colorimetric pH sensor. Journal of Food Measurement and Characterization 11(4): 2180-2194.

Lakowicz, JR, Maliwal B, Ozinskas A, Thompson R.B (1993) Fluorescence lifetime energy- transfer immunoassay quantified by phase-modulation fluorometry. Sensors and Actuators B: Chemical 12(1): 65-70.

Lee K, & KoS (2014). Proof of concept study of a whey protein isolate based carbondioxide indicator to measure the shelf-life of packaged foods. Food Science and Biotechnology 23:115–120.

Mac Craith B, Mc Donagh C, Keefe G, Keyes E, VosJ, Kelly B, McGilp JF (1993)Fibre optic oxygen sensor based on fluorescence quenching of evanescent-wave excited ruthenium complexes in sol-gel derived porous coatings. Analyst 118 :385–388.

Mills A (2009) Oxygen indicators in food packaging. Sensors for Environment, Health and Security 371–388.

Mohebi E, Marquez L (2015) Intelligent packaging in meat industry: An overview of existing solutions. Journal of food science and technology52:3947-3964.

Neethirajan S, Jayas DS (2011) Nanotechnology for the food and bioprocessing industries. Food and bioprocess technology4:39-47.

Nychas G. J. E, Drosinos EH, Board RG (1998) Chemical changes in stored meat. The microbiology of meat and poultry 1:288-320.

Papkovsky DB, Ponomarev GV, Trettnak W, Leary P (1995) Phosphorescent complexes of porphyrin ketones: optical

properties and application to oxygensensing. Analytical chemistry. 67(22):4112-4117.

Pavelkova A (2013)Time temperature indicators as devices intelligent packaging. Acta Universitatis Agriculturae et Silvicul turaeMendelianaeBrunensis 61(1): 245-251.

Restuccia D, Spizzirri UG, Parisi OI, Cirillo G, Curcio M, Iemma F, Picci N (2010) New EU regulation aspects and global market of active and intelligent packaging for food industry applications. Food contro. l21(11):1425-1435.

Rijk R (2008) Legislative Issues Relating to Smart Packaging. Smart packaging technologies for fast moving consumer goods 314.

Roberts L, Lines R, Reddy S, Hay J (2011) Investigation of polyviologens as oxygen indicators in food packaging. Sensors and Actuators, B: Chemical152: 63-67

Smolander M (2003) The use of freshness indicators in packaging. Novel food packaging techniques 127-143.

Smolander M, Chaudhry Q (2010) Nanotechnologies in food packaging. Nanotechnologies in food 14: 86-101.

Taoukis PS, Labuza TP (2003)Time-temperature indicators (TTIs). Novel food packaging t echniques103-126.

Taoukis, PS, (2001) Modelling the use of time-temperature indicators in distribution and stock rotation. Food process modelling 512:402-431.

Trettnak W, Gruber W, Reininger F, Klimant, I (1995) Recent progress in optical oxygen sensor instrumentation. Sensors and Actuators B: Chemical 29(1-3):219-225.

Vanderroost M, Ragaert P, Devlieghere F, De Meulenaer B (2014). Intelligent food packaging: The next generation. Trends in Food Science & Technology. 39 :47–62.

Viswanathan S, Radecki J (2008) Nanomaterials in electrochemical biosensors for food analysis- a review. Polish journal of food and nutrition sciences 58(2).

VuCHT, Won K (2014)Leaching-resistant carrageenan-based colorimetric oxygen indicator films for intelligent food packaging. Journal of Agricultural and Food Chemistry62:7263–7267

Welt BA, Sage DS, Berger KL(2003)Performance specification of time temperature integrators designed to protect against botulism in refrigerated fresh foods. Journal of food science. 68(1): 2-9.

Yam KL, Takhistov PT, Miltz J (2005)Intelligent packaging: concepts and applications. Journal of food science70(1):R1-R10.