



INTELLIGENT FOOD PACKAGING

Semih Otles, Buket Yalcin

Ege University, Bornova-Izmir, Turkey

ABSTRACT. In recent years, Intelligent Packaging and Smart Packaging terms have begun to appear. The definition of these terms is often used interchangeably but generally they are used with different meanings. In this paper intelligent packaging system is defined. First of all traditional packaging system is defined briefly for better understanding of intelligent food packaging system. After this definition intelligent packaging term, applications and systems are defined. Finally some food packaging samples are given with figures.

Key words: packaging, intelligent, food, biosensors, quality.

INTRODUCTION

In traditional packaging; the package is used to communicate with the consumer as a marketing tool, protect the product against the deteriorative effects of the external environment, contain products of various sizes and shapes and provide the consumer with greater ease of use and time-saving convenience. The traditional packaging is no longer sufficient because the society has become increasingly complex today. Although it has contributed to the early development of the food distribution systems.

The aim of food packaging is to protect the food from chemical and microbial contamination, water vapours, oxygen and light. This usage of package has an important role in determining the shelf life of a food. Generally, this role is a rather passive and inert one, but in recent years, the idea of active and intelligent packaging has received more attention and many commercial products have been introduced and used in the food area.

For packaging materials which in contact with food, the general requirements are conventionally concentrated on the safety by restricting the migration of substances from the packaging materials into the food and the consequences of the package on the sensory qualities of the food. The concept of intentional migration of substances, like antioxidants and preservatives from the package into the food are new perspectives for the food packaging which are introduced and these are related with intelligent packaging.

Intelligent packaging is in an early state of development technology that uses the communication function of the package to facilitate decision making to achieve the benefits of enhanced food safety and quality. Thinking the package's outside could be the reason of development intelligent packaging.

In recent years, Intelligent Packaging and Smart Packaging terms have begun to appear. The definition of these terms is often used interchangeably but generally they are used with different meanings. Intelligent packaging could be defined as a packaging system that sensed and

communicated, while smart packaging as one that possessed the capabilities of both intelligent and active packaging. Another definition for intelligent packaging, monitored the conditions of packaged foods to give information about the quality of the food during storage and transport.

Intelligent packaging could be defined; as a packaging system that is capable of carrying out intelligent functions (such as sensing, detecting, tracing, recording and communicating) to facilitate decision making to extend shelf life, improve quality, enhance safety, provide information, and warn about possible problems.

A package can be intelligent if it has the ability to track the product, sense the environment inside or outside the package, and communicate with human. For example, an intelligent package can monitor the safety and quality condition of a food product and provide early warning to the consumer or food manufacturer.

Intelligent packaging could be defined as a packaging technique containing an external or internal indicator for the active product quality and history.



Fig. 1. Intelligent food wrappers
Rys. 1. Inteligentne opakowania żywności

INTELLIGENT PACKAGING APPLICATIONS

Tamper evidence

- breach of pack containment

Quality and safety indicators

- time-temperature indicators (TTIs)
- microbial growth
- gas sensing devices
- pathogen detection

Traceability devices

- radio frequency identification (RFID) chips/tags

Product authenticity

- hidden design print elements-RFID
- holographic images, logos

INTELLIGENT PACKAGING SYSTEMS

1. Indicators

- Time/temperature indicator
- Oxygen indicator
- Carbon dioxide indicator
- Colour indicator
- Pathogen indicator
- Breakage indicator
- Freshness indicator (microbial or pathogens spoilage)
- Leak indicator (tamper proof)

2. Radio Frequency Identification Tags (RFID)

3. Sensors

- Intelligent sensors
- Bio-Sensors
- Gas sensors
- Fluorescence based oxygen sensors



Fig. 2. A kind of time-temperature indicator
Rys. 2. Wskaźnik czasowo-temperaturowy

Time-temperature indicator

This indicator is giving information on temperature and it shows the variation and history in temperature. It is used as supplement to labelling in transportation or storage. If perishable food products are stored above the suitable storage temperature, a rapid microbial growth takes place. The product could be spoiled before the estimated use by date. Time-temperature indicators (TTI) attached to the package surface is designed for integrate the cumulative time-temperature history of the package throughout the whole distribution chain, and therefore, gives indirect information on the product quality. The time-temperature history is visualised as a colour movement or colour change. Time-temperature indicators which are commercially available are based on various reaction mechanisms (diffusion, polymerisation or enzyme reaction). The temperature dependent reaction kinetics of the

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

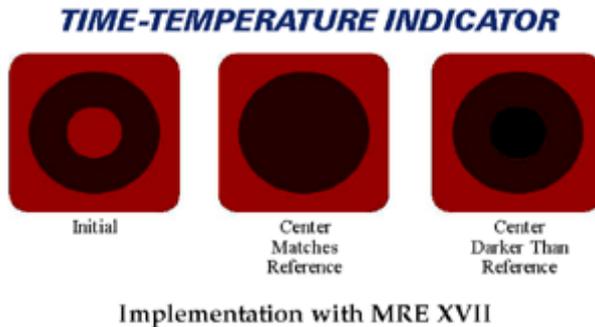


Fig. 3. Working principle of time-temperature indicator

Rys. 3. Zasada działania wskaźnika czasowo-temperaturowego

Oxygen indicator

This indicator is giving information on leakage. The usage area for this indicator is controlled or modified atmosphere food packaging. A typical oxygen indicator consists of a redox-dye (such as methylene blue), an alkaline compound (such as sodium hydroxide) and a reducing compound (such as reducing sugars). Oxygen indicators have been recently described which based on oxidative enzymes. In addition to these main components, such as a solvent (water or an alcohol) and bulking agent (such as silica gel, polymers, cellulose materials, zeolite) compounds are added to the indicator. The indicator can be formulated as a label, a printed layer, a tablet, or it may also be laminated in a polymer film.

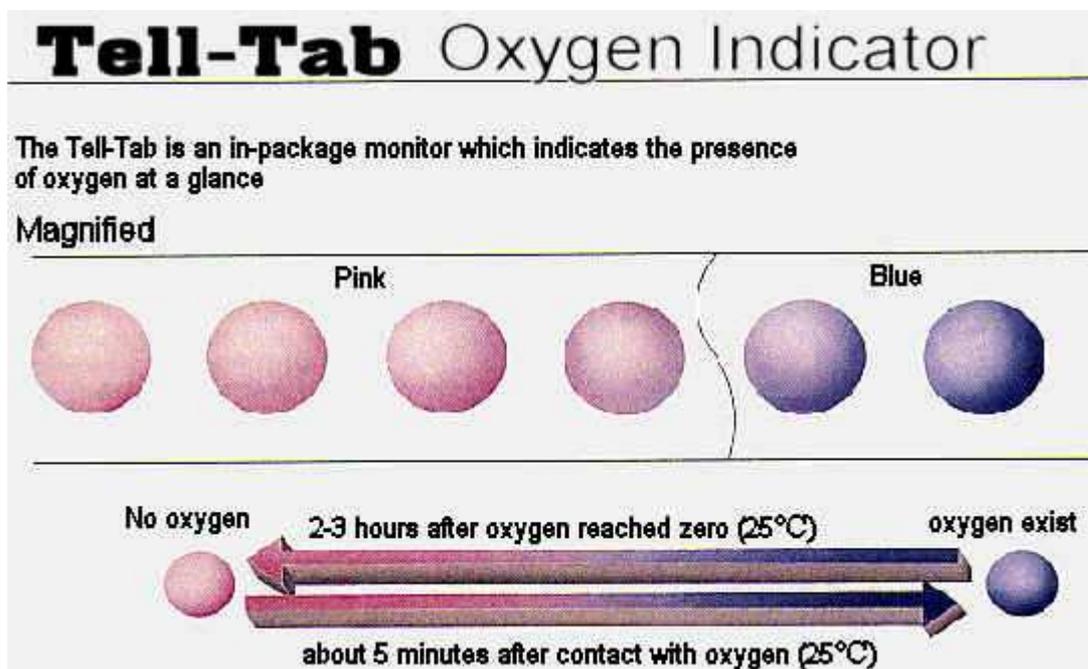


Fig. 4. Working principle of oxygen indicator

Rys. 4. Zasada działania wskaźnika tlenowego

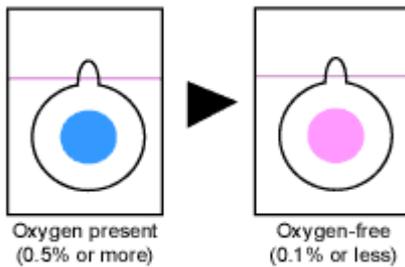


Fig. 5. Sample for color changing in oxygen indicator
Rys. 5. Przykład zmiany koloru we wskaźniku tlenowym

Carbon dioxide indicator

This indicator gives information on concentration of carbon dioxide in modified atmosphere packaging. The usage area of this indicator is controlled or modified atmosphere packaging.



Fig. 6. A sample for oxygen or CO₂ indicator
Rys. 6. Przykład wskaźnika tlenowego lub opartego na CO₂

Colour indicator

This indicator gives information on temperature in food packaging. Food for microwave preparation is the usage area of this indicator.

Pathogen indicator

This indicator gives information on microbiological status and it is used on meat, fish or poultry packaging.

Breakage indicator

This indicator gives information on broken packaging and it is used on canned baby food packaging.

Freshness indicators

Freshness indicators indicate the microbial quality of the product by reacting to the metabolites produced in the growth of microorganisms. A specific indicator material has been developed for the detection of *E. coli* O157 enterotoxin and the possibility for applying the technology for the detection of other toxins is currently being explored. The indicator may be based on a colour change of chromogenic substrates of enzymes produced by contaminating microbes, the consumption of certain nutrients in the product, or on the detection of microorganisms, as such.

Samples for freshness indicators

Toxin Alert -Toxinguard™ (Pseudomonas sp. is measured by freshness indicators)

In polyethylene-based packaging antibodies could also detect pathogens.



Fig. 7. Milk bottle has a freshness indicator that turns from white to red as the level of lactic acid increasing. When the milk has gone sour, the indicator turns to bright red.

Rys. 7. Butelka z mlekiem ze wskaźnikiem świeżości, którego kolor zmienia się z białego na czerwony pod wpływem zwiększenia się poziomu kwasu mlekowego. Gdy mleko staje się kwaśne, wskaźnik przybiera kolor jaskrawo czerwony.

Leak indicators

A leak indicator gives information on the package integrity throughout the whole distribution chain which attached into the package. Exclusion of oxygen and high concentration of carbon dioxide improves the stability of the product as the growth of aerobic microorganisms is prevented for many perishable products. The protecting atmosphere is deteriorated as a result of package leaks. The microbial spoilage is increased with package leaks by enabling the product contamination with harmful microorganisms.

Radio Frequency Identification Tags (RFID)

Wireless data collection technology, uses electronic tags for storing data and identification of animals, objects or people. Tags attached to assets (pallets, cattle, packs, meat bins) to transmit information to a reader.

Tags are could be classified into two categories; first one is passive tag which is cheap, simple, short-range, powered by energy from reader and the second one is active tag which is battery powered, longer range, more information (nutritional information, temperature, cooking instructions etc.).

Intelligent sensors

Devices used to locate, detect or quantify matter or energy, giving a signal for the detection of a chemical or physical property to which the device responds. Most of devices contain two functional units: first one is receptor which is transformed chemical or physical information into a form of energy; second one is transducer which is a device that transforms this energy into a useful analytical signal. The marker concept is; used to determine a primary measurable or a secondary physical, chemical or biological variable. Exacting industry specifications, high development costs and safety considerations have limited commercial realisation although significant steps have been made.



Fig. 8. A sample for working diagram of RFID
Rys. 8. Przykład diagramu opartego na RFID

Bio-Sensors

Compact analytical devices that detect, transmit and record information pertaining to biological reactions.

- Specific to a target analyte (such as; microbes, hormones, enzymes, antigens) is bioreceptor.
- To convert biological signals to an electrical response (such as electrochemical, optical) is transducer



Fig. 9. Direct quality indicator Label indicator of fruit maturation level
Rys. 9. Bezpośredni wskaźnik jakości określający poziom dojrzałości owoców

Gas Sensors

As a result of the activity of the food product, the environmental conditions or the nature of the package, the gas composition in the package headspace often changes. Gas sensors are devices that respond quantitatively and reversibly to the presence of a gaseous analyte by changing the physical parameters of the sensor and are monitored by an external device.

CONCLUSIONS

Intelligent food packaging is an innovative technology which is developing in recent years. The reason of development intelligent packaging is thinking the outside of package. On the other hand to extend shelf life, improve quality, enhance safety, provide information, and warn about possible problems, this packaging technology is developed and also these parameters are the benefits of the system. The disadvantages of the system is the potential migration of the packaging particles into food. By the way the concept of intentional migration of substances, like antioxidants and preservatives from the package into the food are new perspectives for the food packaging which are introduced and these are related with intelligent packaging.

REFERENCES

- Fabech B., Hellstrøm T., Henrysdotter G., Hjulmand-Lassen M., Nilsson J., Rüdinger L., Sipiläinen-Malm T., Solli E., Svensson K., Thorkelsson Á.E., Tuomaala V., 2000. A Nordic report on the legislative aspects, Norden.
- Gontard N., 2003. Active and Intelligent Food Packaging: Technological Evolutions and Safety Evaluation. Joint Research Unit "Agropolymers Engineering and Emerging Technologies" Montpellier.
- Kerry J.P., 2006. Past, current and potential utilisation of active and intelligent packaging systems for meat and muscle-based products: a review. 52nd ICoMST, Dublin, Ireland.
- Murphy A., Millar N., Cuney S., 2003. Active and Intelligent Packaging The Kitchen of the Future. Cambridge Consultants, 4th November 2003.
- Otles S., Yalcin B., 2008. Smart food packaging. *LogForum*, 4, (3), 4, 1-7.
- Popa M.E., 2007. Modified Atmosphere and Intelligent Packaging of Food. USAMV Bucharest-Biotechnology Faculty.
- Veraart J.R., 2006. Current and future EU legislation for smart and intelligent packaging for food. TNO-Knowledge for business. Stockholm.
- Yam K.L., Takhistov P.T., Miltz J., 2005. Intelligent Packaging: Concepts and Applications. *Journal of Food Science*, 70, (1), R1-10.
- Yeza I.A., 2008. Active/intelligent packaging : Concept, Applications and Innovations. 2008 Technical Symposium New Packaging Technologies to Improve and Maintain Food Safety, September 18-19, 2008, Toronto.
- <http://www.food-notes.com>
- <http://www.matbase.com>
- <http://www.mgc-a.com>
- <http://www.nanowerk.com>
- <http://www.natick.army.mil>
- <http://www.sorbentsystems.com>

INTELLIGENTNE PAKOWANIE ŻYWNOSCI

STRESZCZENIE. W ostatnich latach weszły w użycie takie pojęcia jak sprytne pakowanie czy inteligentne pakowanie. Te dwa określenia są często stosowane zamiennie ale w zasadzie odnoszą się do odrębnych spraw. W pracy przedstawiono pojęcie pakowania inteligentnego. Na wstępie krótko zdefiniowano tradycyjny sposób pakowania w celu lepszego zrozumienia nowo wprowadzanego pojęcia. Następnie przedstawiono definicję oraz sposoby i systemy zastosowania pakowania inteligentnego. Na końcu przedstawiono przykłady takich zastosowań.

Słowa kluczowe: opakowania, inteligentne, żywność, biosensory, jakość.

INTELLIGENTE LEBENSMITTELVERPACKUNG

ZUSAMMENFASSUNG. Intelligente Lebensmittelverpackung und smarte Lebensmittelverpackung sind neue Begriffe, die in den letzten Jahren immer häufiger eintreten. Diese Begriffe werden oft austauschbar eingesetzt, allerdings sie haben unterschiedliche Bedeutung. Der Artikel beschreibt den Termin der intelligenten Verpackungssystemen. Am Anfang werden traditionelle Lebensmittelverpackungssysteme definiert um den intelligenten Lebensmittelverpackungssysteme besser zu verstehen. Danach wird der Termin der intelligenten Verpackung als auch Einsatzmöglichkeiten dessen erklärt. Beispiele solchen Anwendungen werden zum Schluss vorgeführt.

Codewörter: Verpackungen, intelligent, Lebensmittel, Bio-Sensoren, Qualität.

Semih Otles
Ege University
Engineering Faculty
Food Engineering Department
35100, Bornova-Izmir, Turkey
e-mail: semih.otles@ege.edu.tr