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SMART FOOD PACKAGING

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ABSTRACT. Nanotechnology is used for food packaging in food industry. Smart packaging can be defined as a new approach for food packaging system. This packaging system can arranged its condition according to environmental changes (like temperature and moisture) and it can be warned consumer when food is contaminated. In this paper nanotechnology, developments on packaging system are defined briefly and than depending on this knowledge smart packaging system is defined. Smart materials and smart package devices are defined for better understanding how smart packaging system is working. Finally food packaging samples are given.

Key words: nanotechnology, packaging, biosensors, indicators.

INTRODUCTION

In recent years nanotechnology applications on food packaging have been introduced. After this development actively exploring the potential of nanotechnology for use in food or food packaging is reported by some largest food companies. According to this definition for understanding smart packaging, nanotechnology and developments on packaging systems are briefly defined.

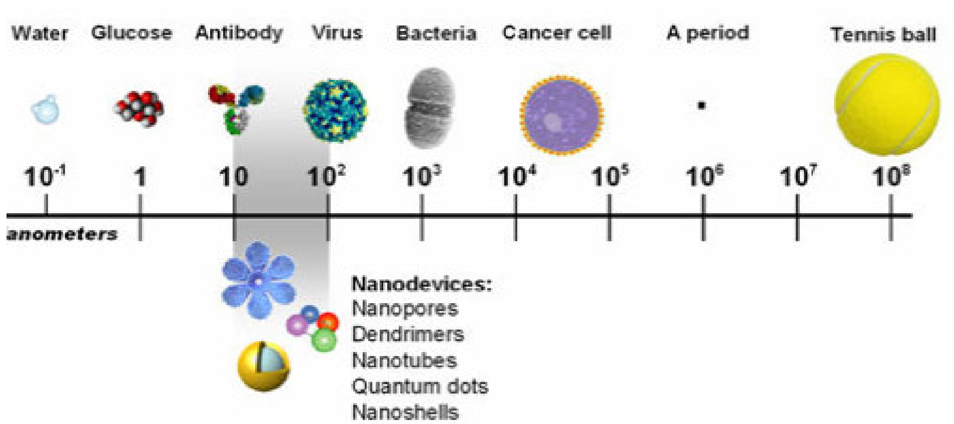

Fig. 1. Development of nanotechnology, scale for nanometers
Rys. 1. Rozwój nanotechnologii, skala w nanometrach

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Nanotechnology can be defined as, an innovative technology which is used to create materials and change structure, enhanced quality and texture of foodstuffs at the molecular level. This technology has a major impact on production, processing, transportation, storage, traceability, safety and security of food.

The basic functions of packaging can be classified into 4 categories: protection, communication, convenience, and containment. In decade traditional packaging systems give place to new packaging systems which include nanomaterials on package, smart packaging system. Packaging in which subsidiary constituents have been included in or on either the packaging material or the package headspace to enhance the performance of the package system can be defined as active packaging. Another definition for active packaging; when packaging performs some desired role in food preservation other than providing an inert barrier to external conditions, packaging can be termed active. Active packaging can be classified as a subset of smart packaging and referred to as the incorporation of certain additives into packaging film or within packaging containers for maintaining and extending product shelf-life.

Smart packaging is being developed through the application of nano-sensors able to detect the release of particular chemicals. The packaging can be engineered to change colour to warn the consumer about food spoilage or contamination by pathogens. Electronic 'tongues' and 'noses' will be designed to mimic human sensory capacities, enabling them to 'taste' or 'smell'. Smart packaging can be considered an all-embracing term used to encompass both intelligent and active packaging, in addition to this packaging design functional and emotional packaging.

Fig. 2. Food packaging today
Rys. 2. Pakowanie żywności w dzisiejszych czasach

SMART MATERIALS

A smart Material is does something to change its environment, and the change triggering the response may be anything from temperature to light levels. Many new, smart materials are being developed and many of them based on plastics and have considerable potential to be used in packaging applications. Materials responsive to: pH, pressure, temperature, gases, liquids, shelf life, biological indicators, contamination.

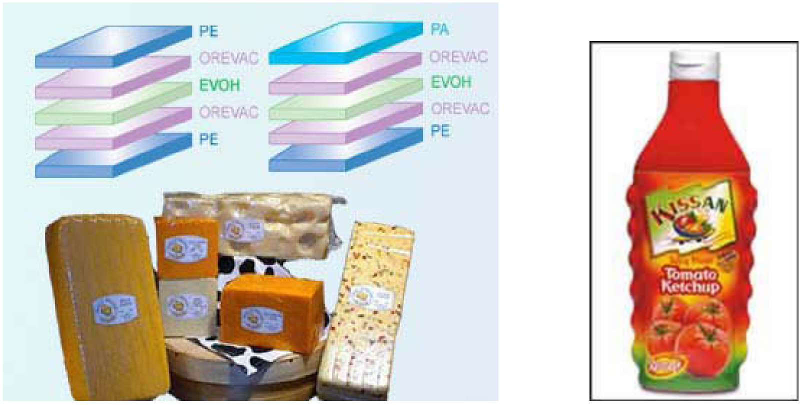

Fig. 3. Ethylene-vinyl alcohol copolymer (EVOH) used in shrinkable films and plastic containers
Rys. 3. Zastosowanie kopolimeru EVOH w kurczliwych foliach i opakowaniach plastikowych

SMART MATERIALS FOR PACKAGING

- Microwave smart windows
- Self-monitoring and healing composites
- Microgels for controlled release
- Techniques for monitoring conformational changes
- Methods for drug release
- Gas and bio-sensors
- Self-assembled monolayers

SMART PACKAGE DEVICES

Smart package devices can be defined as small, economical labels or tags that are attached onto primary packaging (for example, bottles), or onto secondary packaging (for example, shipping containers), to facilitate communication throughout the supply chain so that appropriate actions may be taken to achieve desired benefits in food quality and safety enhancement. 2 basic types of smart package devices are existed: data carriers that are used to store and transmit data, and package indicators that are used to monitor the external environment and, whenever appropriate, issue warnings. A communication channel between the external environment and other components is provided in the system. Multiple smart package devices are employed in an intelligent packaging system at several strategic locations throughout the supply chain.

DATA CARRIERS

Barcodes

Barcodes are cheap and most popular form of data carriers. The UPC (Universal Product Code) barcode was introduced in the 1970s and to be present at the grocery store for facilitating inventory control, stock reordering, and checkout. Very limited information could be containment with meager storage capacity such as manufacturer identification number and item number, leaving no room for encoding additional information. A new barcode symbologies called the Reduced Space Symbology (RSS) is being introduced to address the growing demand for encoding more data in a smaller space.

Some of members are particularly well suited for product identification at point-of-sell and for product traceability in the grocery industry.

The RSS-14 Stacked Omni-directional barcode could be used for loose produce items such as apples where space limitation requires a narrow symbol and encodes the full 14-digit Global Trade Item Number (GTIN). The RSS Expanded Barcode encodes up to 74 alphanumeric characters, and it could be used for variable measure products (such as meat and seafood that are sold by weight) where larger data capacity is required to encode additional information such as batch/lot number, packed date, and package weight.

The PDF 417 (Portable Data File) is a 2 dimensional symbol that carries up to 1.1 kilobytes data in a space of a UPC barcode. Additional information is encoded which is not possible with linear barcodes, such as cooking instructions, nutritional information, web site address of food manufacturer, and even graphics. Portable data's advantage is that they are available immediately, without having to access an external database.

Radio frequency identification tag (RFID) is an advanced form of data carrier for automatic product identification and traceability. Its application in packaging has only begun in recent years. In a typical RFID system, a reader emits radio waves to capture data from an RFID tag, and the data is then passed onto a host computer for analysis and decision making.

A RFID tag could also be integrated with a biosensor or a time-temperature indicator to carry time-temperature history and microbiological data.

This technology is still at its early stages of implementation, the focus is on simple tasks such as product identification and tracking, and not on complicated matters that involve the application of scientific food principles. When RFID technology becomes more established, to develop the necessary decision support system for enhancing food safety and quality; the integration of food science knowledge will be required.

PACKAGE INDICATORS

Time-temperature indicators

Temperature is generally the most important environmental factor influencing the kinetics of chemical and physical deteriorations, as well as microbial growth in food products. Time temperature indicators (TTIs) are typically small, self-adhesive tags attached onto individual consumer packages or shipping containers. These tags provide visual indications of temperature history during storage and distribution, which is particularly useful for warning of temperature abuse for chilled or frozen food products. They are also used for estimating the remaining shelf life of perishable products and called freshness indicators. Some visually distinct changes are usually the responses of these tags that are temperature dependent, such as diffusion of a dye along a straight path and an increase in color intensity. 3 basic types of commercially available TTIs are existed: partial history indicators, full history indicators and critical temperature indicators. Today, affordable and powerful wireless and scanner technologies have provided a more favorable environment for companies to develop advanced TTI systems for controlling and tracking the quality of perishable food products. For example, A TTI/ barcode system has been developed in which data may be read by a hand-held scanner, displayed on a computer monitor, and downloaded into a database for analysis. A battery-powered TTI/RFID tag has been developed and this tag using a technology in which thin-film batteries are printed onto a flexible substrate. Another battery powered TTI/RFID tag has been developed. The TTI/RFID tag uses a microchip to sense and integrate temperature over time to determine the shelf life of a product which is different from the traditional TTI that is based on diffusion or a biochemical reaction.

Gas indicators

The gas composition often changes as a result of the activity of the food product, the environmental conditions or the nature of the package in the package headspace. A package label or printed on packaging films gas indicators can monitor changes in the gas composition, by this way monitoring the quality and safety of food products is provided. The most common gas indicators are the oxygen indicators for food packaging applications, because oxygen in air can cause color change, oxidative rancidity, and microbial spoilage. Many oxygen indicators are designed to show color changes due to leaking or tampered packages. Oxygen indicators are used to detect improper sealing and quality deterioration of modified atmosphere packages which is containing cooked beef or pizza.

A carbon dioxide indicator is used consisting of a carbon dioxide absorbent and a chemical dye in a polymeric film to measure the degree of fermentation in kimchi products during distribution and storage.

The future integration of gas indicators into RFID tags or barcode labels; willenable gas indicator signals to be transmitted also electronically not only visually, is expected. Advances in printing and smart ink technology will also allow gas indicators to be read automatically from a distance using optical systems.

Fig. 4. Smart packaging sample
Rys. 4. Przykłady inteligentnych opakowań

Biosensors

A biosensor is usually a compact analytical device that records, detects, and transmits information pertaining to biochemical reactions. 2 primary components consist of: a bioreceptor that recognizes a target analyte and a transducer that converts biochemical signals into a quantifiable electrical response. The bioreceptor is a biological or organic material such as an antigen, enzyme, hormone, microbe, or nucleic acid. The transducer may assume many forms (such as optical, electrochemical) depending on the parameters being measured. Some important biosensor characteristics are its sensitivity, specificity, portability, reliability, and simplicity. Presently, although several prototypes are being developed, commercial biosensors for intelligent packaging are not available. For example, a biosensor/barcode called Food Sentinel System is being developed to detect pathogens in food packages. A specific-pathogen antibody is attached to the barcode's membrane-forming part; the presence of contaminating bacteria will cause the formation of a localized dark bar, rendering the barcode unreadable upon scanning. A diagnostic system called Toxin Guard is being developed that incorporates antibodies into plastic packaging films to detect pathogens. When the antibodies encounter a target pathogen, to alert the consumer, inspector, or retailer the packaging material displays a clear visual signal. This system is planned for detecting gross contamination, because it is not sensitive enough for detecting very low levels of pathogens that can cause disease.

Fig. 5. NutriSystem'sAquaescentswater bottle uses an aroma-enhanced cap to provide noncaloricflavor to plain drinking water
Rys. 5. Butelka NutriSystem'sAquaescentswater używająca nakrętki ze wzmacniaczem zapachu dla wody pitnej.

FOOD-PACKAGING SAMPLES

Meat Packaging: A new synthetic material has been developed with silver particles for meat packaging. This material is allowing a longer shelf life for meat and anti-bacterial. Longer product shelf life is the main advantage. The uncertainty about whether the silver particles might migrate from the packaging material into the meat is the disadvantage. Negative impacts on health and the environment may also be possible during the disposal process.

Bread: Containing fish oil nanocapsules (a source of omega-3 fatty acids) are integrated in bread. The nanocapsules break open only when they have reached the stomach. Therefore, the unpleasant fish oil taste can be avoided. The advantage is omega-3 fatty acids, which are important for human health is existed in bread. A disadvantage is that much about the effect of these nanocapsules on human health are not known.

Juice: Beta-carotene converts into vitamin A, which is important for the human body. Beta-carotene may be split in small particles, and then it may be encapsulated in starch. This new material can be added to juices. Advantages; the body can better absorb beta-carotene, it can be better dissolved in water, , and the shelf life of juices is longer with beta-carotene. A disadvantage is much about the effect of this product on human health is not known.

Fig. 6. Carbon Nanotubes, Patent to improve color of meat in packaging
Rys. 6.   Mikrokapilary węglowe zastosowane w opakowaniach mięsa

CONCLUSION

Smart packaging system on foods is an innovative technology which is developing in recent years. Development of the system enhanced the performance of package systems.

Packaging that incorporates nanomaterials can be "smart," which means that it can respond to repair itself or environmental conditions or alert a consumer to contamination and the presence of pathogens. Benefits of the system could be classified; extending product shelf-life, enhanced food quality and safety, less use of fat, enhanced absorption of nutrients, improved packaging, traceability and safety of food products for the food sector and also controlling of internal and external conditions of package on marketing level. On the other hand the main risk of consumer exposure to nanoparticles from food packaging is likely to be through potential migration of nanoparticles into food and drinks.

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INTELIGENTNE PAKOWANIE ŻYWNOŚCI

STRESZCZENIE. Nanotechnologia jest stosowana w przemyśle spożywczym w procesie pakowania żywności. Inteligentne pakowanie można zdefiniować, jako nowe podejście do systemu pakowania żywności. Ten system pakowania może dostosowywać własne parametry odpowiednio do zmian otoczenia (jak temperatura czy wilgotność) i dostarczać konsumentowi informacji o tym, że żywność uległa zepsuciu. Praca przedstawia krótko nanotechnologię oraz rozwój systemów pakowania i na bazie tej wiedzy, definiuje system inteligentnego pakowania. W celu lepszego zrozumienia jak działa system inteligentnego pakowania, przedstawiono materiały i urządzenia mające zastosowanie w tym procesie. Zaprezentowano również przykłady tego typu opakowań.

Słowa kluczowe: nanotechnologia, opakowania, biosensory, czujniki.

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