Agri Articles
(e-Magazine for Agricultural Articles)
Volume: 03, Issue: 02 (MAR-APR, 2023)
Available online at http://www.agriarticles.com
©Agri Articles, ISSN: 2582-9882

Intelligent Packaging of Food Products

(*Abdullah Zaid, Ali Khan and Deepak Tomar)
Banda University of Agriculture and Technology, Banda, Uttar Pradesh
*Corresponding Author's email: abdullahzaid265@gmail.com

Although traditional packaging has contributed greatly to the early development of the food distribution systems, it is no longer sufficient because today's society has become increasingly complex. Innovative packaging with enhanced functions is constantly sought in response to the consumer demands for minimally processed foods with fewer preservatives, increased regulatory requirements, market globalization, concern for food safety, and the recent threat of food bioterrorism. How can the existing functions of a mature, and sometimes taken-for-granted, technology be enhanced? It probably requires rethinking and shifting the existing paradigm. Active packaging and intelligent packaging are the results of "thinking outside the box." During the past 2 decades, the popularity of Active Packaging (AP) has signified a major paradigm shift in packaging; namely, the protection function of packaging has been shifted from passive to active. Previously, primary packaging materials were considered as "passive," meaning that they functioned only as an inert barrier to protect the product against oxygen and moisture. Recently, a host of new packaging materials have been developed to provide "active" protection for the product. AP has been defined as a system in which the product, the package, and the environment interact in a positive way to extend shelf life or to achieve some characteristics that cannot be obtained otherwise. It has also been defined as a packaging system that actively changes the condition of the package to extend shelf life or improve food safety or sensory properties, while maintaining the quality of the food.

Definition of intelligent packaging

According to the American Heritage Dictionary, the word "intelligent" is defined as "showing sound judgment and rationality" and as "having certain data storage and processing capabilities." A prerequisite of making sound decisions is effective communication—the ability to acquire, store, process, and share information— and this is where IP can make a significant contribution. We define intelligent packaging as a packaging system that is capable of carrying out intelligent functions (such as detecting, sensing, recording, tracing, communicating, and applying scientific logic) to facilitate decision making to extend shelf life, enhance safety, improve quality, provide information, and warn about possible problems. We believe that the uniqueness of IP is its ability to communicate: because the package and the food move constantly together throughout the supply chain cycle, the package is the food best companion and is in the best position to communicate the conditions of the food.

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 to 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 visualized as a color movement or color change. Time temperature indicators which are commercially available are based on various reaction mechanisms (diffusion, polymerization 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. In fig.1 fruits packed with time and temperature indicator has been shown.

Data Carriers

Data carriers help to make the information flow within the supply chain more efficient. The function of data carriers is not to monitor the quality of the products, but to guarantee traceability, automatization, theft protection, or counterfeit protection. To ensure this, data carriers store and transmit information about storage, distribution, and other parameters. Therefore, they are often placed on tertiary packaging. The most frequently used data carriers are barcode labels and RFID (Radio Frequency Identification) tags.

Freshness Indicators

These indicators allow the quality of food products to be monitored during storage and transportation. Loss of freshness may be due to exposure to harmful conditions or exceeding shelf-life. Freshness indicators offer direct information about a product's quality based on microbial growth or chemical changes. It does so by detecting volatile amines, which are produced when a food product spoils, by conductometric or pH change or similar methods. Freshness indicators work on the principle that the organic acid, carbon dioxide and volatile nitrogen compounds that occur as a result of the microbial growth in the structure of the food that loses its freshness, change the chemical structure of the dye in the indicator. The dye usually changes color as a result of the reaction between the dye and its degradation metabolites. In this way, visible, easily detectable freshness measuring systems can be created. Hydrogen sulfide, ethanol, diacetyl and carbon dioxide are some examples of freshness indicators.

Gas Indicators

These label-shaped indicators are placed in the package and monitor changes in the inner atmosphere due to microorganism metabolism and enzymatic or chemical reactions on the food matrix. It can also be used to monitor the situation of active packaging such as O_2 and CO_2 scavengers. Since they are placed inside the packaging, they must be non-water-soluble and must have a certificate of food contact compliance.

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.

Rancidity Indicator

Lipid oxidation is a complex process that proceeds on a free radical process. Decomposition of hydro peroxides of fatty acids to aldehydes and ketones is responsible for characteristic oxidative rancidity. Enzymatic pathway can also initiate lipid oxidation. Presented in many plants and animals, lipoxygenase is the major enzyme responsible for pigment bleaching and off-odors in frozen vegetables. Moreover, in raw products, hydrolytic enzymes namely lipases and phospholipases, which catalyze the transfer of groups to water, may remain active during frozen storage. These enzymes hydrolyze ester linkages of triacylglycerol and phospholipids, respectively. If they are not in under control during storage, the hydrolysis of lipids can result in undesirable flavor and odor as hydrolytic rancidity.

Radio frequency identification tags

The RFID tag is an advanced form of data carrier for automatic product identification and traceability. Although RFID has been available for many years for tracking expensive items and livestock, its broad 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 (which may be connected to a local network or to the Internet) for analysis and decision making. Inside the RFID tag is a minuscule microchip connected to a tiny antenna. RFID tags may be classified into 2 types: passive tags that have no battery and are powered by the energy supplied by the reader, and active tags that have their own battery for powering the microchip's circuitry and broadcasting signals to the reader. The more expensive active tags have a reading range of 100 feet or more, while the less expensive passive tags have a reading range of up to 15 feet. The actual reading range depends on many factors including the frequency of operation, the power of the reader, and the possible interference from metal objects. Banana with RFID tag has been shown below in fig.2.

Fig. 1

Fig. 2

Biosensors

The broad spectrum of food-borne infections is changing constantly over time as most known pathogens are controlled and new ones have emerged. There is a need for rapid, accurate, on-line sensing for in situ analysis of pollutants, detection and identification of pathogens, and monitoring of post-processing food quality parameters. In general, a biosensor is a compact analytical device that detects, records, and transmits information pertaining to biochemical reactions. This smart device consists of 2 primary components: a bio receptor that recognizes a target and a transducer that converts biochemical signals into a quantifiable electrical response. The bio receptor is an organic or biological material such as an enzyme, antigen, microbe, hormone, or nucleic acid. The transducer can assume many forms (such as electrochemical, optical, acoustic) depending on the parameters being measured. Some important characteristics of a biosensor are its specificity, sensitivity, reliability, portability, and simplicity. Freeze-Damage Indicator indicates Freeze-damaged citrus fruits and display changes that make them inappropriate for consumption. Immediate visible changes include the appearance of spots on the surface of the fruit and the formation of white ice crystals in the interior of the fruit, Ice crystal formation disrupts the pulp cells in frozen fruit and creates pathways for juice to exit the fruit, ultimately leading to the dehydration of freeze-damaged citrus fruits. Adverse chemical changes include variation in volatile composition, formation of limonin, which causes the fruit to have not only a bitter taste but a reduction in total soluble solids and total sugars as well. Non-destructively and rapidly detected the freeze damage in frozen Californian navel oranges using machine vision and ultraviolet fluorescence of tangeritin, a poly-methoxylated flavones, in the peel oil visible on the peel surface and found that visual appearance was different from Oleocellosis, in that freeze-damaged oranges exhibited a fine pattern of 1–2 mm bright-yellow dots on the peel when viewed under long-wave UV light. Using machine vision, a classification accuracy of 87.9% was obtained for unfrozen and moderately or severely frozen fruit, dropping to 64.4% for fruit with low levels of freeze damage. Food Spoilage Indicator An indicator that would specifically demonstrate the spoilage or the lack of freshness of the product, in addition to package leak or temperature abuse, would be ideal for the quality assurance of freezechilled food products. The number of publications on package indicators for spoilage or freshness of food product is still limited. The concepts for visible indicators sensitive to spoilage indicating metabolites, in turn, monitoring status of freshness. A crucial prerequisite in the development of food spoilage indicators is knowledge about relationship between quality indicating metabolites and microbial growth. These metabolites have also been investigated since they provide a possibility to replace time-consuming sensorial and microbiological analyses conventionally employed in the quality evaluation of food products. The formation of different potential marker metabolites in freeze-chilled food products is dependent on the nature of the product type, related spoilage flora, storage conditions, and the type of packaging system. A number of food spoilage indicators can be developed on the basis of indicator metabolites in relation to freeze-chilled food products.

Conclusion

Intelligent packaging for frozen food products has evolved to provide enhanced communication and information at optimized cost. The definition of intelligent packaging is in one way concise and in another comprehensive. Each adds a little to the understanding and from all the facts assembled, there arises certain grandeur. Indicators and RFID in association with frozen food product is latest technology in food packaging industry. Some of the well-known indicators (i.e., integrity indicator, food spoilage indicator and time–temperature indicator) were reviewed. However, possible concepts of other indicators (i.e., freeze-damage indicator and rancidity indicator) were introduced to some frozen food product applications. Radio frequency identification technology as an intelligent tracking packaging for frozen food products has evolved to provide enhanced communication and information at optimized cost. All these indicators mentioned above can be used for long distance transporataion and also for long time storage. Nowadays smart cold storage has been developed which calculate the shelf life of stored products with help of different indicators and RFID tags.