Smart Packaging Technologies for Monitoring Food Freshness

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Abstract-There is no denying the importance of packaging in the life cycle of any food product. Within the food packaging industry, intelligent packaging is a new technology. Although it has not yet reached its full market potential, its significance for preserving food safety and quality has been established. This review covers a number of intelligent packaging topics. In order to preserve the quality of various food items by regulating microbial growth and gas concentration, as well as to give its users convenience and ease in the form of time temperature indication, it first outlines the various tools used in intelligent packaging. All things considered, intelligent packaging can guarantee food safety and quality in the food industry. Nevertheless, there are still some issues with this new technology, such as its high cost and legal implications; therefore, more work should be done to address these issues in order to further promote its uses in the food industry. To maximize the advantages of this new technology, efforts should also be made to integrate multiple separate intelligent packaging devices into a single one.

Index Terms: Food, Freshness, Packaging, Intelligent.

I INTRODUCTION

The majority of food items are extremely perishable, thus in addition to employing preservation methods like freezing, cooling, and drying to increase their shelf life, packaging is also essential. Packaging serves the primary function of shielding food ingredients from environmental dangers. In addition to preserving the food product's quality, it also helps with product distribution and marketing to the end user and offers information on the ingredients. Since maintaining the food product's quality is the most important concern across the whole supply chain, packaging's primary goal is to preserve the food's quality. [1] Modified atmospheric packaging (MAP), edible coating, antimicrobial packaging, and antioxidant packaging are some of the innovative methods that have been developed in recent years. These methods are crucial for meeting consumer demands by prolonging the shelf life and preserving the quality of a range of processed and fresh food goods. [2]

Since modified atmosphere packaging technology was successfully developed and commercialized a few decades ago, MAP has been widely used to package a variety of food products, namely fruit and vegetables, dairy products, muscle foods, bread goods, ready meals, and dried foods. Conversely, intelligent packaging is a recently developed method in the food packaging industry that not only protects the food material but also informs the consumer about the packaged food's environmental state. It should be mentioned that active packaging and intelligent packaging share many similarities. When a package is said to be active, it typically signifies that it does more than just passively contain and preserve food products. [3]

II PRINCIPLES OF INTELLIGENT FOOD PACKAGING

Intelligent packaging: From the perspective of food safety and quality, intelligent packaging helps the industry and customers by providing timely information about the condition of the goods through systemic changes. Certain intelligent packaging solutions have the capacity to notify consumers about the entire history of the food product, including details about the ingredients, manufacturing process, expiration date, and storage requirements. In certain situations, intelligent packaging is made to alert users to a situation that could harm the packaging material or shorten its lifespan. Research has been done on developing such labels or seals that are transparent until the package is opened. Once the package is damaged, the label or seal will change its colour and, in some cases, it will spell out “opened” or “stop”. [4]

Integration of intelligent devices with conventional food packaging: By protecting the food material, conventional food packaging can increase the shelf life of food products. However, it is unable to alert consumers to changes in quality, such as changes in temperature, changes in gas concentrations, or the growth of microorganisms within the package environment.[5] To achieve this, various intelligent components ought to be incorporated into various food packaging systems in order to create an intelligent environment and inform consumers of the package's changing status. [6]

III TYPES OF INTELLIGENT TOOLS USED FOR FOOD PACKAGING

Microbial and chemical analyses can be used to regularly monitor the quality of food as it is being processed. Nonetheless, there are certain quality traits that require ongoing attention across the supply chain. When the quality criterion of the packed foods varies, these smart packaging equipment or devices also undergo some alterations. They are typically placed within the product's packaging to track quality changes, but they can also be placed outside to alert consumers to food goods' safety concerns. Sensors, indicators, barcodes, and radiofrequency identification (RFID) devices are the three primary tool kinds utilized in intelligent packaging, in general. [7]

Sensors: A sensor is a device that can identify, locate, or detect an issue and then send signals to measure its chemical or physical properties. A sensor can occasionally pick up on an event or changes in the surroundings. Typically, sensors consist of a transducer and a receptor. A receiver's job is to transform chemical or physical data into energy, which a transducer then transforms into an analytical signal. Developing intelligent food packaging systems that use portable chemical sensors to evaluate various chemicals and gas molecules, particularly H2, O2, NO2, and CO2, in modified atmosphere packaging may be crucial for ensuring food quality and safety. [8]

These chemical sensors are the best substitutes for labor-intensive analytical tools like gas chromatography-mass spectrometers (GC-MS), which can only be used by rupturing the integrity of food packages. Two light-emitting chemicals made up their created sensor; one may be used to measure temperature, while the other can detect oxygen. Ruthenium tris-1, 10-phenanthroline was utilized as the temperature-sensitive dye because of its strong luminescence. [9] Due to its intense, thermally triggered, and delayed fluorescence at high temperatures, fullerene C70 was the probe utilized to detect oxygen sensitivity. Their findings demonstrated that the dual sensor could detect temperature changes between 0 and 120 °C and that the oxygen detection limits were as low as 50 ppmv. [10]

Indicators: Indicators of time and temperature are used to determine whether a food product is at or above a given temperature. Additionally, it provides users with information about the presence of microorganisms and the structural alterations in proteins that occur throughout various food processing procedures. Indicators of freshness provide information about the quality of food by examining microbial development and/or chemical alterations in food items. However, to check the gas concentration inside the packaging system, gas indicators are employed as labels. [11]

• Time-temperature indicators : The storage duration of a particular food product is determined in large part by temperature. The quality of processed food materials is greatly concerned when there are abrupt fluctuations in temperature. [12]

• Gas indications : Maintaining the quality of food materials within the packaging system is extremely difficult for a variety of reasons, including fresh fruit and vegetable respiration, shifting gas concentrations, gas leakage from the packaging materials' interior or exterior, or gas generated by microbial growth inside the package. The introduction of gas indicators is intended to address these issues. The most common forms of gas indicators are labels, tablets, printed layers, or laminated in polymer films. In order to detect oxygen gas and stop colours from leaking out of the packaging material, a better and simpler oxygen gas indicator was created. [13]

• Freshness indicators : Freshness indicators are designed to check for microbial development and notify consumers about the freshness of food goods. These gadgets give data on food rotting and microbiological development, which are indicators of product quality. Various organic acids (like lactic or acetic acid), glucose, ethanol, volatile nitrogen compounds (like trimethyl amine for packaged fish products), carbon dioxide, biogenic amines (for chicken and beef), and sulfuric compounds are typically used to create food freshness indicators that assess the freshness of the packaged food items. [14]

• Barcodes and radio frequency identification devices (RFID) : RFID tags and barcodes are primarily data-carrying devices. Multi-scale department stores frequently use bar codes to speed up pricing checking, record keeping, and product restocking. Barcodes typically consist of a systematic arrangement of side-by-side lines that conceal encoded data. An optical barcode scanner decodes and decodes the message, sending the appropriate message to a system where it is stored for future action. [15]

Three main parts make up RFID tags: a microchip-based tag attached to a tiny aerial, a reader that can both emit and receive radio signals, and a network system or web server that links the business and the RFID devices. The majority of sophisticated RFID devices have a 1MB storage range and can receive data up to 100 meters away. Active and passive tags are the two types of tags that make up the current RFID system. In contrast to passive tags, which do not have a battery inserted, active tags use a battery. [16]

IV INTELLIGENT PACKAGING SOLUTIONS IN SUPPLY CHAIN

Foods are delicate goods, therefore throughout the supply chain, their qualitative characteristics deteriorate. Throughout their life cycle, constant attention to detail is required. There should be a system that can closely monitor the food product from the field to processing and then from a valuable product to its end users. Additionally, consumers want food products that entail fewer preparation procedures and greater convenience. Additionally, these food items ought to be fresh and offer superior qualities. [17]

Provision of convenience to consumers: Due to their hectic lives and busy schedules, most individuals now consider convenience to be essential. The creation of intelligent films that can be used for both conventional and microwave heating is a breakthrough in convenience. This can be accomplished by mixing crystalline polyethylene terephthalate (CPET) and amorphous polyethylene terephthalate (APET), allowing their properties to be mixed for storage and heating purposes. In order to reduce the temperature of the packaged food product, amorphous polyethylene terephthalate (APET) is utilized as a packaging material in conjunction with CPET. [18]

Marketing and branding of food products: Packaging is a major factor in food product branding and marketing since it influences consumers' decisions to buy the product in the first place. Thus, one excellent strategy for boosting food product sales is clever packaging. Including information on the quality and safety of the particular food product on the packaging, together with visually appealing features and attractions, enables customers to make more informed decisions. [19]

Controlling counterfeiting and theft : The food industry and customers worldwide are concerned about theft, counterfeiting, and tempering. In addition to the widely used RFID system, bar codes, thermo-chromic inks, dyes, holograms, tear taps, specialized laser labels, and electronic tags, some unique closures that can identify the tempered food products have also been developed to combat the risk of food product theft and counterfeiting. Before they reach the end user, these closures made of plastic and aluminium degrade during any effort at counterfeiting. a non-destructive quality analysis device for a typical Italian cheese that is integrated with an electronic tracking system. [20]

V CONCLUSION

In the food packaging industry, intelligent packaging is a new development. This technology has the potential to give consumers higher-quality food items. Consumers can receive higher-quality and fresher food goods by utilizing practical equipment like gas concentration indicators, freshness indicators, time temperature indicators, etc. Likewise, the industry, retailers, and customers can use bar codes, RFID tags, thermo-chromic inks, holograms, and tear taps to prevent food products from being stolen or counterfeited. Intelligent packaging has a very bright future thanks to technological advancements. It should be possible to replace the current intelligent packaging system with advanced technologies, including electronic labelling that uses a chip and ink technology to produce labels. Future packages are anticipated to have the capability of chatting with users. Additionally, food packaging containers might be made using thermochromic materials, which would change the color of the container and shield the food ingredients from direct sunlight. It is anticipated that all of the separate devices, including freshness, gas concentration, and temporal temperature indicators, will soon be able to be combined into a single device. A powerful and practical tool for giving information about the food product's quality attributes would be such a combination single gadget. Thus, for the effective development of intelligent food packaging, combined advanced research in the fields of electronics, mechanical engineering, and food engineering should be carried out. In this sense, intelligent packaging ought to be able to contribute significantly to improving the safety and quality of perishable food ingredients.

REFERENCE

[1] Nopwinyuwong, A., S. Trevanich, and P. Suppakul. 2010. Development of a novel colorimetric indicator label for monitoring freshness of inter mediate-moisture dessert spoilage. Talanta 81:1126–32.

[2] Han, J. H. 2014. Intelligent packaging for food products.Innovations in food packaging, 2nd Ed., 171–209. Amsterdam: Ed. ElsevierAca demic Press.

[3] Intelligent sensing and packaging of foods for enhancement of shelf life: concepts and applications. International Journal of Scientific & Engineering Research 3 (10):1–13.

[4] Robertson, G. L. 2012. Food packaging: Principles and practice. 3rd ed. Boca Raton, Florida, USA: Taylor & Francis.

[5] Yam, K. L. 2012. Intelligent packaging to enhance food safety and quality. Emerging food packaging technologies: Principles and prac tice, ed. K. L. Yam, andD. S. Lee, 139. Philadelphia:Woodhead Publishing Limited.

[6] Amin, E. M., N. C. Karmakar, and B. W. Jensen. 2016. Fully printable chip less RFID multi-parameter sensor. Sensors and Actuators A: Physical 248:223–32. Bagchi, A. 2012.

[7] Llobet, E. 2013. Gas sensors using carbon nanomaterials: a review. Sensors and Actuators B: Chemical 179:32–45.

[8] Eom, K. H., M. C. Kim, S. J. Lee, and C. W. Lee. 2012. The vegetable fresh ness monitoring system using RFID with oxygen and carbon dioxide sensor. International Journal of Distributed Sensor Networks 8(6):1–6.

[9] Rahman, M. A. 2016. RFID based tracing for wine supply chain. International Journal of Communication Networks and Distributed Systems 16 (1):48–70.

[10] Hogan, S. A., and J. Kerry. 2008. Smart packaging of meat and poultry products. Smart packaging technologies for fast moving consumer goods, ed. J. Kerry, and P. Butler, Chapter 3. West Sussex, UK: John Wiley & Sons Ltd.

[11] Keller, K. L. 2003. Strategic brand management: Building, measuring and managing brand equity. 2nd ed. Englewood Cliffs: Prentice-Hall.

[12] Mohebbi, B. 2014. The art of packaging: An investigation into the role of color in packaging, marketing, and branding. International Journal of Organizational Leadership 3:92–102.

[13] Hogan, S. A., and J. Kerry. 2008. Smart packaging of meat and poultry products. Smart packaging technologies for fast moving consumer goods, ed. J. Kerry, and P. Butler, Chapter 3. West Sussex, UK: John Wiley & Sons Ltd.

[14] Amin, E. M., N. C. Karmakar, and B. W. Jensen. 2016. Fully printable chip less RFID multi-parameter sensor. Sensors and Actuators A: Physical 248:223–32.

[15] Pareek, V., and A. Khunteta. 2014. Pharmaceutical packaging: Current trends and Future. International Journal of Pharmacy and Pharmaceu tical Sciences 6 (6):480–85.

[16] Keller, K. L. 2003. Strategic brand management: Building, measuring and managing brand equity. 2nd ed. Englewood Cliffs: Prentice-Hall.

[17] Robertson, G. L. 2012. Food packaging: Principles and practice. 3rd ed. Boca Raton, Florida, USA: Taylor & Francis.

[18] Kerry, J. P., O'Grady, M. N., & Hogan, S. A. (2006). Past, current and potential utilisation of active and intelligent packaging systems for meat and muscle-based products: A review. Meat Science, 74(1), 113–130.

[19] Restuccia, D., Spizzirri, U. G., Parisi, O. I., 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 Control, 21(11), 1425–1435.

[20] Vanderroost, M., Ragaert, P., Devlieghere, F., & De Meulenaer, B. (2014). Intelligent food packaging: The next generation. Trends in Food Science & Technology, 39(1), 47–62.