Review Article

Intelligent Packaging for Food: A Review

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Abstract
Intelligent packaging plays salient role to minimize food waste of perishable and minimally processed food. This is an evolving technology to inform customers related to food without interfering in food package. Intelligent packaging technology works on the basis of chemical changes, enzymatic reaction and microbial activity of packed food. According to the nature of the food different type of indicators, sensors and RFID tags are used to determine actual quality of food. Changes in food quality can be converted to readable form by intelligent packaging technology. Intelligent packaging technology can work efficiently to monitor quality of different types of food with different application of indicators, sensors or RFID tags. Intelligent packaging technology is new and developing technology, so that it is expensive as compared to other packaging technology. Intelligent packaging will be becoming more widely used in future with new innovations in this field.

Keywords: Indicators, Intelligent packaging, RFID, Sensors

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Introduction

Many years ago, packaging had been practiced to protect food from different environmental impacts and to ease of supply. Now a days packaging does not just represent covering of food material, but it also offers benefits like, maintaining or extending shelf-life, monitoring food quality and safety too. The packaging practice also offers the other advantages by differentiating products from alternative competitors, improving exposure on store shelves and adding value to itself through the design and shape of packet [1].

The packaging is the fifth-largest sector of India’s economy which is growing rapidly. In 2019, India's packaging industry was worth USD 50.5 billion, and by 2025, it is predicted to be worth USD 204.81 billion. In India, the packaging industry is developing at a rate of 22 to 25 per cent every year, according to the Packaging Industry Association of India (PIAI) [2].

Packaging is a system in which freshly produced or processed products are reached to consumers in safe condition from production centre. Packaging is defined by the International Packaging Institute (IPI) as the wrapping of products, commodities, or packages in a pouch, bag, box, cup, can, bottle, or other container form. Packaging provides prevention of natural deterioration, physical protection and safety to the product. Appropriate packaging makes product convenient to filling, sealing, storage and shift from one place to another. It also informs details of product to the consumer like, details of product and producer, ingredients, nutritional facts, price, shelf life, handling practices, etc. The product can be identified easily by customers. It should be attractive and colourful according to the product. The packaging of product can also increase the demand of product.

Intelligent packaging is defined as packaging that contains an external or internal indicator to provide information about aspects of the history of the package and/or the quality of the food. The term "intelligent" is defined by the American Heritage Dictionary as "having specific data storage and processing skills" and "showing sound judgement and rationality". Contribution of intelligent packaging is effective as it has ability to acquire, store, process and share information [3]. Active and intelligent packaging are examples of packaging technologies that promise to produce items that are safer and of higher quality. Unfortunately, we use intelligent and active packaging alternatively but actually, active packaging refers to the incorporation of additives into the package with the aim of maintaining or extending the product quality and shelf life. Intelligent systems are those that monitor the actual situation of packaged food in order to provide information about its quality during transportation and storage [4].

Active packaging is packaging in which subsidiary elements have been purposefully put in or on the packaging material or the package headspace in order to increase the package system's performance [5]. Indeed, 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 without any damage to the packaging material [6, 7].

In the packaging practice, it is not possible to check the actual condition of the food packed in that particular package without interrupt packaging material. To solve this problem, intelligent packaging is very helpful. The purpose of intelligent packaging is to give information about the condition of food without any interruption in packaging practices. Packaging is the last output of production and first input of marketing.

The EFSA (European Food Safety Authority) defines intelligent packaging materials as “materials and articles that observe the state of packaged food or the environment in which it is stored”. Intelligent packaging technologies are able to check the state of packed foods and provide information on their quality during transportation and storage [8]. Intelligent packaging systems, which can be attached as labels or stickers, incorporated into, or printed onto food packaging materials, improve the ability to monitor product quality, trace the critical parameters, and provide information about the product such as product history [9]. Consumers can get benefit from product transparency provided by intelligent packaging.

Intelligent packaging is a technology in its early stages of development that uses the package's communication function to aid decision-making in order to attain the benefits of improved food safety and quality. Some factors should be considered when using an intelligent packaging system for food. The indicator should be affordable and not add much to the package's overall cost. It should not be toxic and should not be water soluble. Approval for use in food-contact materials should be granted to the sensor components. It should also be easy to be checked by an untrained individual without requiring expensive technology for analysis.

Materials and Methods

Indicators

Under normal atmosphere packing conditions, when the food within a sealed container starts to spoil, several chemical changes are there inside the packaging atmosphere. As a result, one or more of these chemical changes may possibly be used to detect spoilage. The generation of heat, acidity, pressure, and carbon dioxide are all by-products of food spoilage. There are different types of indicators work on the basis of different principles and are used for different purposes. Time/temperature indicators (TTIs) are popular intelligent visual indicators and they are indirect indicators based on polymerization rate, diffusion, chemical or enzymatic reaction. On the other side, direct indicators are preferred because they can provide more accurate and targeted information on the basis of quality attributes [10].

Time/temperature indicator

The time temperature indicator is an intelligent packaging design that is leading the way in packaging technology. Temperature is one of the most dominant factors that affect the quality of food and safety if it changes [11]. A time temperature indicator is defined as a simple and inexpensive device as compared to other indicators that can show an easily detectable, time-temperature dependent change which determines the full or partial history of temperature of a food product to which it is attached [12].

Most TTIs which have been produced and worked on the basic principle of mechanical, chemical, enzymatic or microbiological processes. These principles are usually expressed as visible responses in the label with the help of an irreversible colour change [13]. Based on their response mechanism, TTIs have been classified as 3 types: critical temperature indicators, partial-history indicators and full-history indicators [14].

The TTI is useful because it can inform consumers when foods have been exposed to extreme temperatures. The quality of food can deteriorate much quicker, if the food is exposed to a temperature higher than that suggested. TTIs are especially effective when it comes to chilled or frozen meals, as cold storage throughout transportation and distribution is critical for food quality and safety [15]. The shelf life of various perishable products can also be estimated by TTIs as freshness indicators.

The Timestrip measures the amount of time that has passed at a specific temperature by using a continuous passage of liquid through a membrane. This activity can reveal the length of time a product has been opened or used. The Timestrip is particularly beneficial for products that must be refrigerated and utilised within a certain time frame, such as sauces. [16]. A typical time indicator and temperature indicator are shown in **Figures 1** and **2**, respectively. As well as list of companies that provide TTIs is given in the **Table 1**.

A commercialized biological time temperature indicator (TTI) as a food quality and safety was evaluated for cold smoked salmon [17]. It should be validated that the TTI endpoint corresponds to the traced food's shelf life under the applied time temperature profile. The data were used to evaluate the microbial contamination distributions acquired at the TTI endpoint and the end of the simulated profiles. This study suggests that the use of the traceability device could make the consumer eat the exposed products more rapidly thus reducing the number of unacceptable products by approximately 50% which is an interesting achievement in the field of food quality and safety.

Active Chitosan-PVA (Poly-vinyl alcohol) films with anthocyanin as Time-Temperature indicators have been developed from Red Cabbage for application in intelligent food packaging [18]. Chitosan is a nontoxic biopolymer and has antimicrobial properties. Chitosan can be blended with other polymers such as PVA to improve its mechanical properties. Anthocyanin was incorporated with Chitosan-PVA film to determine changes in colour of the film according to the pH of the food product. This biodegradable film has shown red to pink colour variation while pH range was 1.0 to 4.0 and it has shown green colour with alkaline pH range. This type of chitosan-PVA films can be used to monitor milk spoilage with change in colour of the film according to the pH of the milk.

Fadable ink-based time temperature indicator was fabricated to check freshness of food [19]. Ink was made up of anthraquinone derivative sodium anthraquinone β-sulfonate which is sensitive to oxygen, so that it will lose its intense red colour to its original beige colour with defined time period. The duration of colour change depends on component of ink, background layer of indicator, substrate, coating material and coating thickness. This type of time temperature indicator is easy to fabricate and monitor time and temperature.

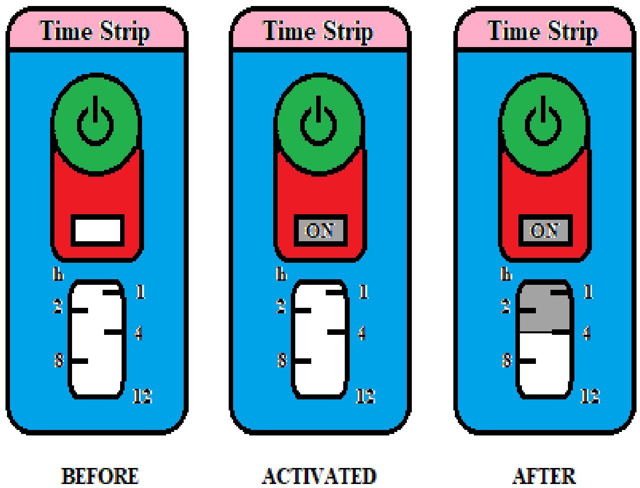

Figure 1 Time indicator

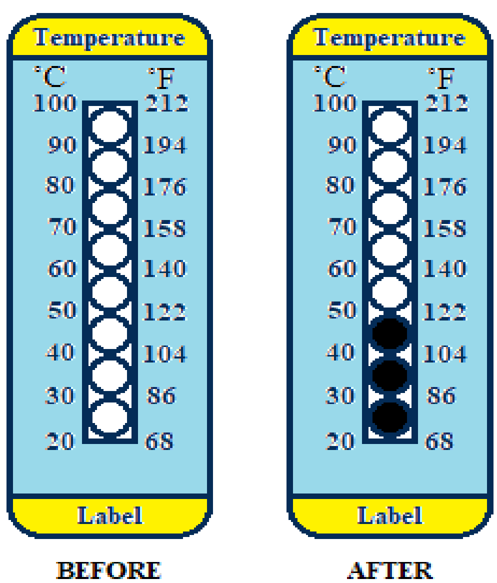

Figure 2 Temperature indicator

Table 1 List of companies manufacturing Time Temperature Indicators

Company	City, State
Reblon Films Pvt. Ltd.	Gurgaon, Haryana
Vpl Chemicals Private Limited	Bengaluru, Karnataka
Vanprob Solutions	Mumbai, Maharashtra
Arham Scientific Co.	Mumbai, Maharashtra

Gas indicators

After packing of food in packaging material, atmospheric change has been occurred due to respiration of food, microbial spoilage and/or leakage of gas through the packaging film from the surrounding air. Gas indicators can monitor the changes in gas composition inside the package and thus can help to monitor the quality of the products [3].

Gas indicators can be used in controlled or modified atmosphere packaging (MAP). In MAP, gas indicators monitor the atmospheric condition by direct contact with atmosphere of packaging. These indicate the change in gaseous atmosphere and will provide the information through indicator by changing its colour. Presence of oxygen is the most common reason of food spoilage [20]. As a result, oxygen indicators are typically employed in food packaging, as shown in **Figure 3**.

A redox dye (such as methylene blue), an alkaline chemical (such as sodium hydroxide), and a reducing compound (such as reducing sugars) make up an ideal oxygen indicator. Oxygen indicators based on oxidative enzymes have recently been introduced. Bulking agents like silica gel, polymers, cellulose materials or zeolite compounds and solvents such as water or alcohol are major components added to the fabrication of indicator [21].

The indicator can be made up of a label, a printed layer, a tablet, or a polymer film laminated with it. For use in food packaging, printable oxygen and carbon dioxide sensor formulations have been developed [22]. By monitoring the degree of quenching of a fluorescent ruthenium complex contained in a sol-gel matrix, the oxygen was measured. When the product is exposed to oxygen within the package, it turns from its original pink colour to blue or purple, and as the level of oxygen is reduced a reversion of the colour occurs.

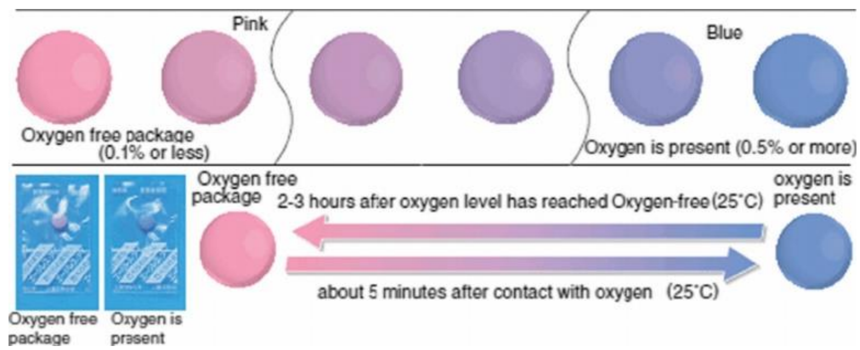

Figure 3 O_2 gas indicator [23]

On-pack, continuous gas composition indicating optical sensors are appealing, and numerous researchers have designed and tested them for monitoring MAP package integrity. Optical CO_2 sensors can be classified into two types (a) the sensors which function based on the colour (colorimetric) change of a pH indicator dye, such as thymol blue, phenol red, cresol red, etc. [24-26] and (b) those based on the CO_2 induced fluorescence change of a luminescent dye [27, 28] such as ruthenium (II) complexes and 1-hydroxypyrene trisulfonate.

Mostly carbon dioxide is used in Modified Atmosphere Packaging (MAP) to inhibit the aerobic spoilage microbes [29]. Because the quality of MAP-packed food is ultimately determined by the package's integrity, leakage detection is a critical component of MAP technology [30]. Carbon dioxide is known to be created during the growth of bacteria and mould on foods. As a result, just detecting CO_2 levels is the perfect technique to indicate food deterioration, and such detectors would have to operate without interfering with other food attributes such as pH, salt content (corrosiveness), pressure or vacuum.

Several physical properties, such as colour, volume, turbidity; chemical properties, such as pH, acidity, CO_2, sugars, salts, etc.; and microbiological properties have been studied to sense ripeness of fermented vegetable dishes like kimchi [31]. However, even during storage and distribution, commercially packed kimchi products often endure a continuing natural fermentation process. As a result, normal testing procedures cannot detect ripeness/over-ripeness without damaging the packaging materials [32]. Therefore, a sensor that can continuously monitor CO_2 gas level and signal level non-destructively by displaying different colours has been developed as shown in **Figure 4**. During fermentation, changes in CO_2 concentration within the kimchi package showed a sigmoid increase. A colour-changing sachet that reacts to CO_2 levels has been created for use in kimchi packaging [33].

Freshness indicator (microbial or pathogens spoilage)

One-third of the world's food production is wasted each year owing to microbial deterioration [35]. Consumers can check the product by its colour, odour and texture because it is limited to check microbial contamination with naked eyes or sense [36]. Consumers cannot identify microbial spoilage or freshness of product. Consumption of spoiled products can cause the risk of food borne diseases. So that, freshness indicators are very useful for food manufacturers, retailers as well as final consumers. A freshness indicator is a packing technique (or material) that provides quick information about the quality of a product. Using microbial growth metabolites, which reveal changes occurring within the food, rather than simply suggesting temperature abuse or package leakage [37].

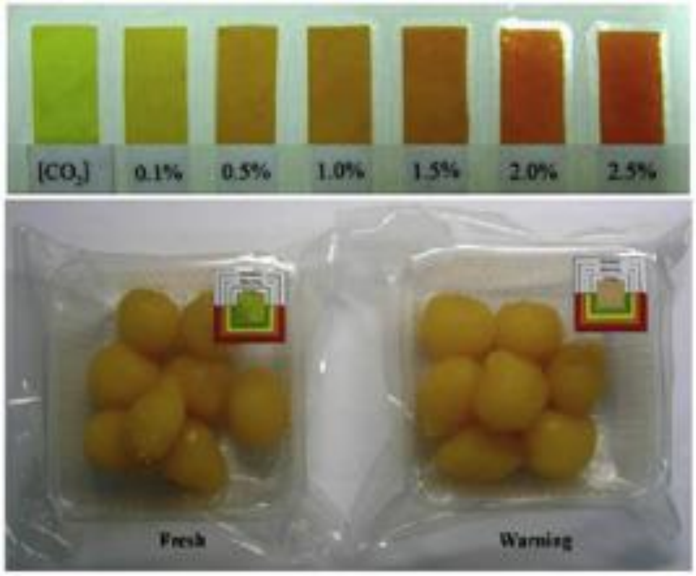

Figure 4 CO_2 gas indicator [34]

The microbiological quality of a product can be determined by reacting to metabolites created during microorganism growth. A specialised indicator material for the detection of E. coli O157 enterotoxin has been developed, and the prospect of using the technology to detect other toxins is currently being investigated. The indicator could be based on the colour change of chromogenic substrates of enzymes produced by contaminated microbes, the consumption of specific nutrients in the product, or the detection of microorganisms in general [38].

The world's first intelligent sensor label, RipeSenses (Jenkins Group, Auckland, New Zealand; www.ripesense.com), can colorimetrically indicate the degree of preferred ripeness for fruits (designed for pears). Central Institute of Fisheries Technology (CIFT), Kochi, Kerala has been developed smart paper-based freshness indicator to monitor freshness of packed fish. It is made up of locally available materials like, filter paper and dye. Fish is highly perishable product and it produces spoilage formation which may affect the consumers' health. This paper-based strip is attached inside the package without direct contact with fish. This strip will react with volatile compounds produced by fish and gives change in colour, which can be read by consumers [39] as shown in **Figure 5**.

On-package colour indicator based on bromophenol blue (BPB) has been fabricated and tests have been conducted to determine the freshness of guava [40]. Bromophenol blue was immobilized onto bacterial cellulose membrane via absorption method. As the volatile compounds produce in the package headspace, pH will decrease. The BPB/cellulose membrane, which acts as a pH indicator, changes colour when the pH drops. For over-ripe indication, the colour of the indicator will shift from blue to green, which is visible to the naked eye. The results demonstrated that the colour indicator may be used to detect the freshness of the guava at room temperature (28-30 ˚C). The pH of the headspace of the guava package is reflected in the colour change of the indicator. Therefore, the indicator can be used for real time visual monitoring of freshness state of packaged guavas.

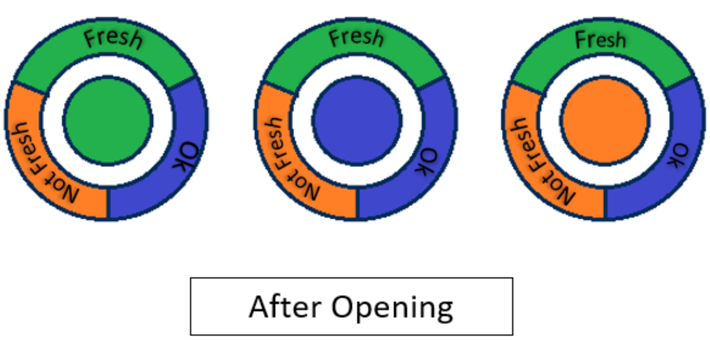

Figure 5 Freshness Indicator

Methyl red based freshness indicator was selected for monitoring of Broiler Chicken cut freshness [41]. The methyl red or cellulose membrane is sensible to volatile amines produced in headspace of package. pH will increase according to the increase in spoilage volatile amines. Methyl red is sensitive to pH change. As a result, the methyl red based indicator's colour changes from red to yellow to indicate spoilage, which is plainly visible to the naked eye. The results show that the methyl red based indicator could be used to determine the degree of chicken cut freshness, as the relationship between the colour change of methyl red as an indicator response and the chicken cut freshness follows a similar trend.

A pH-sensing based freshness indicator on bacterial cellulose nanofibers and anthocyanin of black carrot was developed and used to monitor rainbow trout and common carp fish fillet freshness [42]. Bacterial cellulose (BC) nanofibers were used to fix anthocyanin in indicator label. Fish fillets were packed in cellophane material and indicator labels were attached inside and outside of the material to monitor colour changes. The indicator was able to display colour change from red to khaki according to the change in pH from the range of 2-11. Anthocyanin-incorporated BC membrane indicator took less than one min to change the colour as compared to black bean anthocyanin with 5 sec. It is depended on the purity of material used to fabricate indicator. Anthocyanin- incorporated BC membrane indicator can be used to check freshness of fish fillets during storage because colour change of the indicator was judged by naked eyes.

Radio Frequency Identification Device (RFID)

RFID is not a sensor or an indicator. It's a wireless data gathering system that uses electronic tags to store and identify data. Tags are attached on assets in order to communicate data to a reader. It is wireless communication technology which has been used for tracking expensive items since 1980s [43]. In 2005, Walmart is the first supply chain which have introduced RFID system [44]. RFID is most advanced technology as compared to manual systems or barcodes because it is more accurate and can be read without the need of visual contact [45].

Tags are classified into two categories; (a) passive tag which is cheap, simple, short-range, powered by energy from reader and (b) active tag which is battery powered, longer range, collect more information (nutritional information, temperature, cooking instructions etc.). Common RFID frequencies range from low (125 kHz) to UHF (860-960 MHz). Day by day, RFID systems are becoming popular as a result of their multiple applications, including security monitoring and access control, as well as supply-chain tracking in many food industries. RFID tags can be attached to foods, automobiles, pharmaceuticals, clothing and even pets.

This system consists of a tag, a reader and a central node or computer. A tag is a small device which is made up of RFID chip, an antenna and a substrate. Each tag has unique identity, which helps to track the product. Readers are devices that provide wireless signals to tags in order to identify the item attached to each tag. When the tag receives the message, it responds by sending its information to the reader. After that, the signals are sent to a computer system that is running RFID software as shown in **Figure 6**. Different types of RFID tags are used according to the nature of the food, packaging material and storage condition as shown in **Figure 7**. There are number of companies that manufacturing RFID tags as listed in **Table 2**.

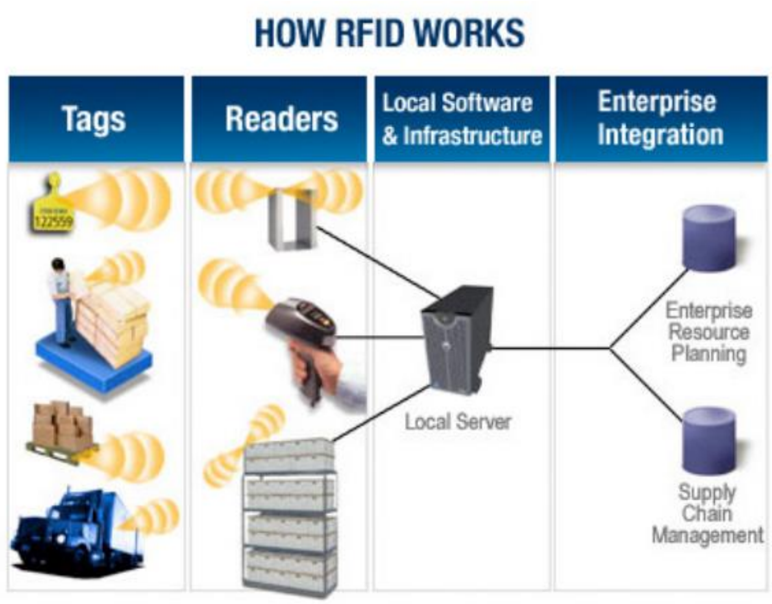

Figure 6 Working principle of RFID tags [38]

Figure 7 Different types of RFID tags [48]

Printed RFID tags had been developed for smart food packaging [46]. Low power resistive tags were developed to measure humidity and availability of volatile amine compounds. In this case study the smart tags were used to quantify the freshness of cod fish. A Nafion humidity sensor's response in resistance were measured as a function of relative humidity. Resistive sensors were created to measure humidity in a cost-effective manner. The ionic conductivity of an electrolyte was used to create humidity sensors. Screen printed silver electrodes were used to make the tag, which was read out using an MSP430 microprocessor. Large changes in resistance were observed with varying humidity.

Battery less RFID tags were used to evaluate the stage of fruit ripening into low-cost intelligent packaging [47]. UHF (Ultra High Frequency) band (860–960 MHz) type RFID tag, which has activation range of 10 m was used to monitor ripeness of Avocado fruit. Avocados were contained inside Polyethylene terephthalate (PET) shells and the tags were attached to the internal (basal or equatorial) side of the shells. This UHF RFID tag was acted as an electromagnetic transducer which converts the chemical–physical changes of fruit during storage into a modulation of the electromagnetic parameters that can be read by the reader. These parameters can be classified into three-level states of the fruit that are unripe, ripe and overripe. It is found that the process to classify state of Avocado fruit was 85% accurate.

Table 2 List of companies manufacturing RFID tags

Company	City, State
APK-ID	Noida, Uttar Pradesh
Digant Technologies Pvt. Ltd.	Bengaluru, Karnataka
Eco Track System	Delhi
Essen RFID	Mumbai, Maharashtra
Greenfuturz	Chennai, Tamil Nadu
India Labels	Bangalore, Karnataka
Megma RFID & Labels Pvt. Ltd.	Noida, Uttar Pradesh
Omnia Technologies	Gurugram, Haryana
Perfect RFID	New Delhi, Delhi
PROFUSION INDIA CONSULTING	Chandigarh
RapidRadio	Ahmedabad, Gujarat
SIVA IoT	Verna, Goa
The Tag Factory Engineering RFID Solutions	Noida, Uttar Pradesh
Vicinity RFID Solutions Pvt. Ltd.	Mumbai, Maharashtra

Sensors

A sensor is a device which detects and converts a physical quantity into a signal that can be read by an observer or instrument. Sensors can divide into three types, namely (a) physical sensors. It is a device that provides information about a physical property of the system. (b) Chemical sensors, which use chemical or physical responses to measure chemical compounds. It's a device that converts chemical data into a signal that can be analysed. (c) Biosensors, which use a biological sensing element to measure chemical compounds. All of these devices have to be connected to a transducer to get visible responses.

Biosensors

A biosensor consists of two types of elements, bio-element and a sensor-element. The bio-element may be an enzyme, antibody, living cells, tissue and the sensing element may be electric current or electric potential. Several types of biosensors are made up of different combinations of bio-elements and sensor-elements to suit a wide range of applications.

The basic principle of biosensor technology is to convert biologically active analyte into readable form with the help of detector as shown in **Figure 8**. There are three basic components of biosensor, (a) biologically active material, (b) detector element and (c) signal processor. There are different types of components used to detect targeted analyte. Biosensors can be applicable in the food industry to monitor specific analyte at real-time and a feedback control. This will increase the food safety and also provide less effective control, less employment, time and energy saving [49].

A study was carried out for the use of biosensor to check the quality of milk [50]. This study was concern of the adulteration of urea in milk, called "synthetic milk". This urea biosensor is formed of immobilised urease-producing bacterial cell biomass *Bacillus sphaericus*. This biosensor is connected to a potentiometric transducer's ammonium ion selectivity electrode. Milk samples were collected and analysed for the presence of urea using a biosensor that had a reaction time of less than two minutes. The results were depended on purity of enzyme system. However, it is worth to mention that since milk is a complex system it contains much interference, which makes conventional methods less reliable.

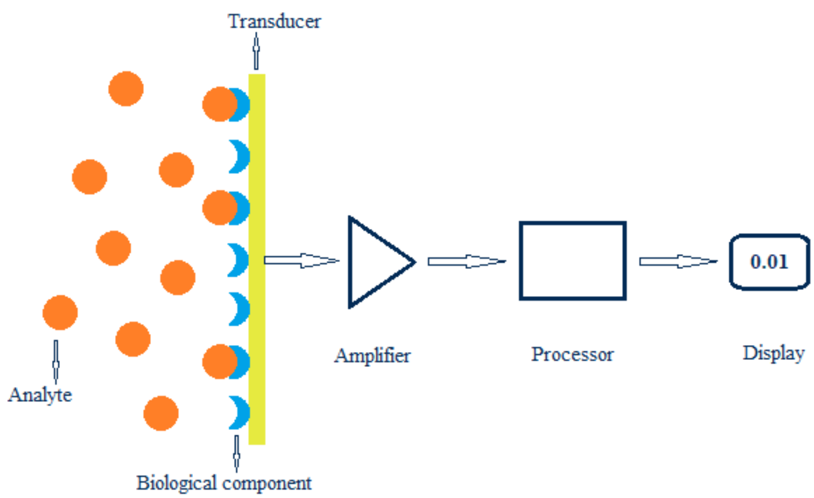

Figure 8 Structure of biosensor technology

An amperometric hypoxanthine (Hx) biosensor was developed for the determination of hypoxanthine in fish and meat [51]. Hx is accumulated in fish and meat tissue during storage period. So that, Hx indicator can be used to determine freshness of fish and meat. Xanthine oxidase (XO) had been used as immobilized bio-component of Hx biosensor. This biosensor was developed to analyse Hx in the range of 0.05 to 2 mM. While the determination of freshness Hx reacts with oxygen in presence of XO to produce uric acid (UA) and hydrogen peroxide (H_2O_2). In this reaction, H_2O_2 can be estimated amperometrically by the platinum anode with the application of polarizing voltage. As Hx is released by the product current of loop will increase. This biosensor provides a simple and rapid method for the determination of Hx in fish and meat tissue.

Gas sensors

Based on the activity of the food product, the gas composition in the headspace of the package often changes according to the environmental conditions or the nature of the package. Gas sensors are instruments that change the physical properties of the sensor to respond quantitatively and reversibly to the presence of a gaseous analyte and are monitored by an external device [52]. Gas detection systems currently include amperometric oxygen sensors, potentiometric carbon dioxide sensors, metal oxide semiconductor field effect transistors, organic conducting polymers, and piezoelectric crystal sensors [53].

Optical oxygen sensing instruments and materials which suitable for intelligent packaging applications are composed of a solid-state material based on the principle of luminescence quenching or absorbance changes as a result of direct interaction with the analyte [54, 55] as shown in **Figure 9**. In contrast to conventional systems, the optochemical sensor is chemically inert, meaning it does not participate in chemical processes or consume analyte. [56]. By monitoring gas analytes such as hydrogen sulphide, carbon dioxide, and amines, it is possible to improve quality control by detecting product deterioration or microbiological contamination. Approaches to optochemical sensing have included: (1) a fluorescence-based system which uses a pH sensitive indicator [57], (2) absorption-based colorimetric sensing realized by visual indication [25] and (3) energy-transfer approaches with the help of phase fluorimetric detection [58].

Gas sensor array was used to monitor food quality and safety [59]. They have used different types of gas sensors for the foods like, fruits and vegetables, dairy products and oil. Gas sensor includes a gas-sensitive material which was activated by an operator. As the sensor was activated in its working temperature, the gas-sensitive material had started a chemical reaction and causes a change in electric resistance. Contaminated food is generally detected by odour. Comparison of different types of sensors were carried out on the basis of selectivity, sensitivity, reliability, robustness, reversibility, energy consumption, fast response time, minimum cross-sensitivity and low cost. Most effective gas sensor is suggested for the particular food item on the basis of different parameters.

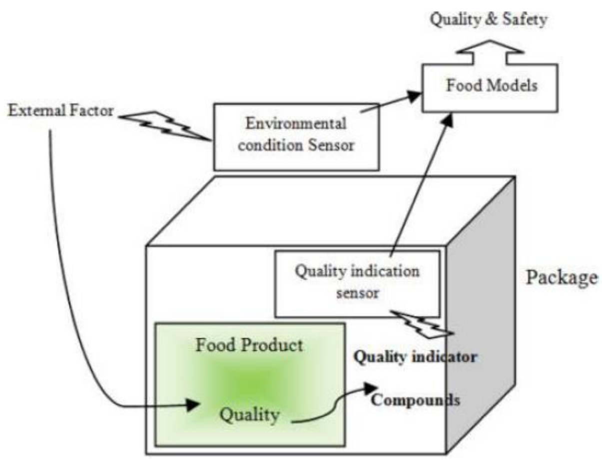

Figure 9 Performance of gas sensor [60]

Fish freshness has been evaluated using gas sensors by odour emitted from fish like salmon and sardine [61]. An oxidation-reduction (ORP) gas sensor, ammonia (NH_3) gas sensor and hydrogen sulfide (H_2S) gas sensor were selected to examine odour from putrefied fish. Two volatile compounds, Dimethylamine (DMA) and trimethylamine (TMA) produced during fish decomposition were selected and the response of the sensor system to them was measured. Principal component analysis (PCA) technique has been used to analyse signals received from the sensors. In this study, H_2S sensor did not respond to DMA and TMA. But, after 2 days of storage, putrefaction was detected by ORP and NH_3 sensors. So, it is concluded that ORP and NH_3 sensors can be used to detect freshness of fish.

Conclusion

Intelligent packaging is very interesting field with convenient way to reduce food waste. There are many options available to apply intelligent packaging for food to monitor the shelf life of food. The main advantage of this technology as compared to other packaging technology is to monitor the food product without any interfere in the package. There are different applications of intelligent packaging according to the nature of the food and packaging practices. So, mostly all indicators, sensors or tags can be used to monitor perishable food products. Most of indicators work on the basis of different changes in the head space of packed food.

Even though, it is not easily accepted by food packaging industries. There are many reasons for this problem. Importance of intelligent packaging has been proven for the maintenance of food quality and safety, although it still needs its full emergence in the market. This technology is still in developing stage, so it cannot be applicable for all type of foods. It is also expensive technology as compared to other packaging technology. So, it can be used for highly perishable and expensive food products. Active and intelligent packaging will be becoming more and more widely used for food products in future.

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