USE OF INDICATORS IN INTELLIGENT FOOD PACKAGING

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Abstract

Nowadays due to changes in life styles and with the increased demand for minimally processed foods, studies for packaging of these products gained popularity. Intelligent packaging system, one of the new techniques which is studied in recent years; provides health and safety of the product for the consumer and also monitor the condition of packaged foods to give information about shelf life and regarding the quality of the food during transport and storage. In this technique indicators and sensors (easy to use small devices) are used instead of time consuming, expensive quality measurements for improving the shelf life and providing food safety. In smart packaging system indicators give information about product quality by surrounding conditions and head space gases of packages, also indicators can be attached to the package surface or integrate to packages which are improved for determining metabolite residue formed during storage. Temperature, microbial spoilage, package integrity, physical shock, freshness of the packaged product can be controlled. In this study usage areas and improvements of time-temperature, leakage and freshness indicators which are in intelligent packaging system are explained.

Keywords: Intelligent packaging, food, time-temperature indicators, leakage and freshness indicators.

Intelligent packaging

Every product, even organically grown foods, needs some sort of packaging during its existence for protection during transportation, handling, storage and use. The package is used to protect the product against the deteriorative effects of the external environment, communicate with the consumer as a marketing tool, provide the consumer with greater ease of use and time-saving convenience, and contain products of various sizes and shapes (Yam et al.,2005). Increasingly hectic lifestyles are creating new consumer demands from products and packaging, particularly in terms of user convenience (Butler, 2004). Over the past decade new technologies such as, controlled packaging, which includes aseptic and retort packages, MAP/CAP, sous vide and biodegradable packaging, edible films and coatings, active packing and smart packing system have improved. The intelligent systems are aiming to monitor the quality of the food product or its surrounding environment to predict or measure the safe shelf-life better than a best before- date (Jong et. al.,2005). Intelligent packaging can be also defined 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 (Yam et al., 2005). Intelligent packaging systems attached as labels, incorporated into, or printed onto a food packaging material offer enhanced possibilities to monitor product quality, trace the critical points, and give more detailed information throughout the supply chain (Han et al., 2005). In this system; sensor technologies, indicators (including integrity, freshness and time-temperature (TTI) indicators) and radio frequency identification (RFID) are evaluated. Many intelligent packaging concepts involve the use of sensors and indicators. Sensors can be applied as the determinant of a primary measurable variable or, using the marker concept, as the determinant of another physical, chemical or biological variable (Kress-Rogers, 1998). Different gas sensors and biosensors have a widely usage area in the food industry (Abad, 2009).

Time/temperature indicators (TTIs)

A time-temperature indicator or integrator (TTI) may be defined as a device used to show a measurable, time temperature dependent change that reflects the full or partial temperature history of a food product to which it is attached (Taoukis & Labuza, 1989). These indicators or integrators are used as cost-effective and user-friendly devices to monitor, record, and translate the overall effect of temperature history on food quality in the chill chain down to a product unit level (Vaikousi et al., 2008). This is a relatively new technology which allows determination of the impact of a process on a product attribute. The major advantage of TTIs is the ability to quantify the integrated time–temperature impact on a target attribute without information on the actual temperature history of the product. Time temperature integrators are an alternative to temperature based methods such as thermocouples. TTIs present some advantages over thermocouples; they are small, and can be made neutrally buoyant and from materials with the same thermal conductivity as food particles. The time–temperature history of the product is not needed to determine the impact of thermal treatments. TTIs are devices which contain a thermally labile substance. Under a heat treatment, the encapsulated substance will undergo irreversible changes which can be quantified as a F or P value (Van Loey et al., 1996). TTIs for food quality monitoring has been extensively reviewed and has been applied to the optimization of the chill chain management of fish and meat products in many studies. TTIs have also been applied in evaluations of the quality of various food products, including frozen vegetables, dairy products, meat and poultry, fresh seafood, and fresh mushrooms (Vaikousi et al., 2008). TTIs can be classified according to their working principle (biological, chemical, physical), response (single, multi), origin (extrinsic, intrinsic), application (dispersed, permeable, isolated) and location (volume average or single point) (Van Loey, 1996). To be able to use a particular TTI as a quality indicator for a specific food product it is necessary that the energy of activation (Ea), indicating the temperature dependence of the TTI response, matches the Ea of the food product. Besides the Ea, the shelf-life of the product also has to be known in order to select appropriate TTIs, as the response time of the TTI (time when the end point is reached) should equal the shelf-life of the product (Bobelyn, 2006).

Freshness indicators

Freshness indicators provide direct product quality information resulting from microbial growth or chemical changes within a food product. Microbiological quality may be determined through reactions between indicators included within the package and microbial growth metabolites (Smolander, 2003). As yet the number of practical concepts of intelligent package indicators for freshness detection is very limited. Despite this, considerable potential exists for the development of freshness indicators based on established knowledge of quality indicating metabolites. The chemical detection of spoilage of foods provide the basis for which freshness indicators may be developed based on target metabolites associated with microbiologically induced deterioration. A variety of different types of freshness indicators have been described (Smolander, 2003), the majority of which are based on indicator colour change in response to microbial metabolites produced during spoilage. The Fresh-Check® TTI (Temptime Corp., Morris Plains, NJ, USA) are based on a solid state polymerization reaction, resulting in a highly coloured polymer. The response of the TTI is the color change measurable as a decrease in reflectance. The colour of the 'active' centre of the TTI is compared to the reference color of a surrounding ring. Before use the indicators, active from the time of production, have to be stored deep frozen where change is very slow. The OnVuTM TTI (Ciba Specialty Chemicals & Freshpoint, SW) is a newly introduced solid state reaction TTI. It is based on the inherent reproducibility of reactions in crystal phase. Photosensitive compounds are excited and coloured by exposure to low wavelength light. This colored state reverses to the initial colorless at a temperature depended rate. This TTI can take the form and applied as a photosensitive ink. Due to enzymatic changes; decreases in pH via controlled enzymatic hydrolysis of a lipid substrate, leading to a color change in the indicator, e.g., the Vitsab TTI (Vitsab A.B., Malmo¨, Sweden) and due to microbial changes, the acidification of the TTI medium by selected lactic acid bacteria, induces a color change in the indicator, e.g., the Cryolog TTIs (Cryolog S.A., Quimper, France), also the (eO) ® TTI (CRYOLOG, Gentilly, France) is based on a time-temperature depended pH change caused by controlled microbial growth that is expressed to colour change through suitable pH indicators. The TT SensorTM TTI (Avery Dennison Corp., USA) is based on a diffusion-reaction concept that causes the color change of the indicator from yellow to bright pink. The 3M Monitor Mark® (3M Co., St. Paul, Minnesota) is based on molecular diffusion of proprietary polymer materials. A viscoelastic material migrates into a diffusely light-reflective porous matrix at a temperature dependent rate. The response rate and temperature dependence is controlled by the tag configuration, the diffusing polymer's concentration and its glass transition temperature and can be set at the desirable range (Taoukis, 2006).

Leakage indicators or sensors

Leakage indicators or sensors attached to the packaging ensure the integrity of the package in the distribution chain. Leak indicators; used in modified atmosphere packaged of meat products were researched generally in the studies. A commercially available patented (Ageless Eye, Vitalon, and Samso-Checker) indicators provide information about the oxygen and carbon dioxide leakage in meat products. As the use of MAP and oxygen scavengers increases and consumers demand more information about the food they eat, especially with regard to its quality and security, so will the demand increase for the over use of intelligent inks, such as the oxygen indicators. Luminescence-based indicators, such as the OxySense2 system, are already being used in food-packaging research. OxySense is the first commercially available fluorescence quenching sensor system for measurement of headspace or dissolved oxygen in transparent or semi-transparent, sealed packages. The system uses an oxygen sensor (O2xyDote) placed in the package before filling and is non destructive, rapid (measurements take less than 5 s) and able to withstand pasteurisation temperatures without loss of sensitivity. Examples of commercially available dual action combined carbon dioxide generators/oxygen scavengers are Ageless G (Mitsubishi Gas Chemical Co., Japan) and FreshPax M (Multisorb Technologies Inc., USA). Carbon dioxide emitting sachets or labels can also be used alone. The Verifraise package, manufactured by SARL Codimer (Paris, France) has been used to extend the shelf life of fresh meats (Kerry et al., 2006; Mill, 2005).

Conclusion

In recent years, smart packaging systems are outstanding between the studies on the technique of packaging. Indicators which give information about the freshness of the food, completeness, reliability for the microbiological quality, status of the temperature and shelf-life constitute an important part of smart packaging system. The quality of the food can be traced through the stages of distribution and storage with the indicators which have different working principles,. Thus, food safety is provided in terms of both manufacturers and consumers by using these indicators in smart packaging technology. In this study we focused on indicators and principles of operation. Studies for the development of commercial indicators will be useful for both industry and literature.

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