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Management

INNOVATIONS FOOD PACKAGING TECHNOLOGIES: FUTURE AND QUALITY PROSPECTIVE

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ABSTRACT

Innovation in food packaging is mainly represented by the development of active and intelligent packing technologies, which offer to deliver safer and high-quality food products. Active packaging refers to the incorporation of active component into the package with the aim of maintaining or extending the product quality and shelf-life. The intelligent systems are able to monitor the condition of packaged food in order to provide information about the quality of the product during transportation and storage. These packaging technologies can also work synergistically to yield a multipurpose food packaging system. The trend towards sustainability, improved product safety, and high-quality standards are important in all areas of life sciences. In order to satisfy these requirements, Innovative packaging technology is used in the food sector. These systems can monitor permanently the quality status of a product and share the information with the customer. In this way, food waste can be reduced and customer satisfaction can be optimized. Depending on the product, different types of Innovative packaging technologies are used and discussed in this review. The main objectives of this review article are to provide basic knowledge of different new and innovative food packaging techniques about their way of preservative action, effectiveness and suitability in various types of foods. Finally, current challenges and future trends are reviewed to highlight the importance of concentrating efforts on developing new functional solutions.

INTRODUCTION:

Novelty and recent trends in food packaging techniques are the result of consumer preferences toward mild processed food products with enhanced shelf life and convenience Moreover, modern trend of retail practices and changing lifestyle are the incentives for the evolution of novel and innovative packaging techniques without compromising food safety and quality characteristics. Rapid growth of novel packaging in food segment is contributed by the enormous use of packaged foods, rising need of prepared foods like use of microwave meals and growing use of smaller size food packages. Another important reason for innovative food packaging is the rising issues of food borne microbial outbreaks which demands the use of packaging with antimicrobial effects along with retention of food quality Innovations in packaging started earlier in the form of electrically driven packaging machinery, metallic cans, aseptic packaging, flexible packaging, aluminum foils and exographic printing. Additionally, the introduction of various materials, viz. polyester, polypropylene, and ethylene vinyl alcohol polymers led to drastic evacuation from metal, paperboard and glass packaging to plastic and exible packaging. Moreover, in 21st century more advancement in packaging technology appeared as intelligent or smart packaging and active packaging (oxygen scavengers, antimicrobial agents, respiration controllers, and aroma/odor absorbers) The emerging changes in packaging industry will strengthen the economy by improving food safety, quality and by minimizing product losses. In an attempt of changing market opportunities packaging industry has resulted in succession of numerous niche markets Since these newer ideas of active, intelligent and bioactive packaging had a greater impact on marketing of food, their way of action and suitability for food applications is mentioned in the following sections.

Active Packaging

Active food packaging represents an improvement in the function ascribed to the classical packaging, aiming to increase product shelf-life by interacting with food or the environment surrounding food. A thorough definition of "active materials and articles" is given by European Regulation 450/2009/EC. It defines them as "designed to deliberately incorporate components that would release or absorb substances into or from the packaged food or the environment surrounding the food". Indeed, conventional food packages are usually intended as passive barriers, which protect food by segregation against environmental contaminations, while active packaging promotes an active action of the packing material providing enhanced food conservation. This active action may be due to particular features that belong to the packaging material or to active agents, which are added to the passive barrier in order to work as absorbers, emitters or releasers of compounds that are able to play a pivotal role in food preservation. Thus, the main target of active packaging is to prevent microbial and chemical contamination, as well as to maintain visual and organoleptic properties of food.

Innovative packaging technologies:

Functional barrier consists of one or more layers of food-contact materials and it should ensure the compliance of product with Article 3 of regulation 1935/2004/EC and Regulation 450/2009/EC. As, per dentition the substances at the rear side of functional barrier will not, migrate in the food and thus will not have deleterious effects on human health nor will result in unacceptable changes in the composition and organoleptic properties. This implies that these intelligent and active sub- stances do not arise from the concern of safety issue which is not also required by Regulation 450/2009/EC and certain sub- stances can be used at the rear side of functional barrier pro- vided they migrate through the functional barrier below a certain detection limit. In case of articles for infants and other susceptible persons the prescribed limit of un authorized sub- stances that might through the functional barrier should not exceed 0.01 mg per kg food.

The quality of food can be maintained by preventing adsorption, desorption, diffusion of gases, liquids, penetration of other molecules such as oxygen, pressurized liquid or gas, and water vapor by the use of high-barrier packaging. The process of poly- mer blending, coating, lamination, or metallization is used to enhance the barrier property of packaging materials by combining the package materials with other high-barrier materials. The structural network of blend of packaging material with high barrier packaging material affects its permeability. Combining high-barrier materials on packaging material by the process of lamination or coating provides laminar structure, the permeability of which decreases linearly with the square thickness. The process of blending with platelets or droplets of high- barrier materials also reduces permeability but the decrease is less as compared to coating or lamination at the same mass as that of high barrier materials. Most commonly used blends are aluminum-metallization on PET, polyethylene terephthalate (PET) lamination on coextruded polypropylene/ polyethylene, polymers with planar clay parti- cles, mixture of beeswax in edible polymer as particulate system lms and polyvinylidene chloride (PVDC) coating on oriented polypropylene (OPP).The innovative technique used to improve barrier property with commercial applicability include epoxy spray on PET bottles, transparent vacuum-deposited or plasma-deposited coating of silica oxide on PET lms and composites of plastics with nano particles.

The safety concern related to active and intelligent packaging should be addressed based on following three important considerations:

Labeling: Proper labeling should be done in order to prevent misuse and misunderstanding by the consumers or downstream users, e.g. to prevent sachets from being eaten.

The migration of active and intelligent substances with respect to their toxicity should be kept in consideration and their migration process should comply with food legislation. Monitoring the phenomena of migration means to adapt some mass transfer modeling tools and migration tests other than those applied or recom- mended for conventional plastics, as they cannot be adapted to active and intelligent systems. The safety concern in case of active packaging is to determine the adequacy of analytical methods used in migration stud- ies to detect as well as quantify to which the consumer would be exposed to, and at what level. Potential migration outside the packaging is considerably reduced as the systems do not require migration testing as there will be a "functional barrier"

Efficient packaging: Most importantly the claimed function of food packaging in few cases can give rise to safety concern as for any food preservation technology. e.g. delivering a preservative or absorbing oxygen in a suitable way for preventing microbial growth without inducing antimicrobial resistance or pathogen over growth, or giving reliable information on pathogenic bacteria presence for direct indicators

Future trends

Nanotechnology is likely to play important part in the near future keeping in consideration the safety concern associated with packaging. To address the safety as well as other additional issues research and development in the eld of active and intelligent packaging grew at dynamic pace with the aim to provide eco friendly packaging alternatives. This posed a challenge of designing packaging materials by employing reverse engineering approach on the basis of requirements of food product besides on the availability of packaging materi- als. The aforementioned approach resulted in the tailoring of stimulated/controlled release of active agents and for speci c target indicators. Another area of development is the use of innovative non-migratory materials in case of functional in- package food processing.

Future advances of active packaging

The advancement in the area of active food packaging led to the development of stimuli-responsive polymer materials. These unique materials offer amazing, innovative and functional features that fully comply with existing environments and regulate the release of molecules in response to external stimuli. As a consequence to retain biological function and provide particular chemical function, selectively designed molecular assemblies which allow release of active ingredients only when required by the system have been recently designed. These stimuli-responsive macromolecular nanostructures are tailored to bring about conformational as well as chemical changes as a reaction to external stimuli such as change in chemical composition, temperature or pH.

Advantages and Disadvantages of Innovative food Packaging Concepts

In general, intelligent packaging is easy to use and provide a number of advantages for consumers, food manufacturers, and the whole food industry. Depending on the system they offer different features.

The current quality status of a product can be determined by the use of indicators and sensors. This results in a general increase of product safety and in a reduction of unnecessary food waste. In addition, this consistent quality monitoring also reduces time and material costs in the analysis methods of packaged food. Further cost advantages also arise along the supply chain when intelligent packaging minimizes food waste. These aspects could be even more important in other life sciences like the pharmaceutical industry.

Data Carriers enable better traceability of the supply chain. Because of their low price, ease of use, and the benefit they provide, barcodes and QR Codes are nowadays widely spread. In contrast, indicators and sensors can be barely found on the market. One reason for this is the price as the development and production costs are still very high. The packaging costs can amount to 50–100% of the total costs of the final product. Actually a limit for packaging costs of 10% of the products value to be packaged is provided. Furthermore, the use of indicators and sensors could lead to a negative change in consumer buying behavior: Customers would most likely put products with a discolored freshness indicator back on the shelf and choose a product with an uncolored freshness indicator. If the customer often sees labels of a brand product with a divergent color, he could even loose his confidence in that brand. At the same time, this behavior could also lead to an increase in unsold foodstuff. On the other side, intelligent packaging can optimize the classic "first in—first out" principle. As the real current quality status of the food is known, the retailer can sell the products with the shorter shelf life first and so the wastage of food could be reduced.

It must be ensured that the systems are compatible with the food to be monitored. Not every intelligent packaging can be used for each type of food. Therefore, it must be clarified which indicator or sensor is appropriate for the product. The intelligent packaging can only be advantageous if it matches with the food. For instance, an oxygen sensor would be useful for MAP (Modified Atmosphere Packaging) packaged foods, while for chilled and frozen products a TTI should be apply.

Another aspect that still needs to be clarified is the recycling of the packaging. The additional waste generated by the installation and production of intelligent packaging is actually contradictory to the goal of reducing the amount of food wastage. It should also be noted that it is not possible to rely a 100% on intelligent packaging for optimum product quality as misuse or failure of the systems cannot be ruled out. Several factors are often responsible for the loss of quality. Monitoring just one parameter cannot provide a complete statement about the quality status of a product. Furthermore, external environmental influences such as light, temperature or mechanical stress can sometimes have an adverse effect on the technologies. On the one hand this can lead to a situation, where products are classified as no longer fit for consumption, even though they still are. On the other hand, this can result in a situation in which the spoilage of a product is not indicated. In the worst case, the consumer's health may be adversely affected if the products are consumed. To sum up it can be said that the robustness of the systems must be improved and the individual packaging technologies should be combined in order to exploit as many advantages as possible.

CONCLUSION:

Nowadays, the market for active, intelligent, and smart food packaging is rapidly increasing with more than 40 billion worth of packages being sold in 2021 and about 50 billion expected by 2026 However, such systems are still scarcely applied due to their high cost compared to traditional packaging materials and the limited possibility of integration within the existing packages. In this sense, the recent developments in chemistry, microelectronics, materials science, engineering, biotechnology, and nanotechnology may help in the design and fabrication of efficient, novel packaging solutions suitable for large-scale applications. For instance, food quality optical detection systems based on colorimetric sensors display great potential to overcome the current challenges, including the high cost and the requirement of sophisticated instruments. Such systems may, indeed, provide a simple and easily readable indication concerning food quality over a long time period. Additionally, the sensitivity of such colorimetric devices and sensors may be even enhanced by integrating them with an RFID, aiming to achieve improved safety and quality, while reducing food waste and limiting costs. Specifically, on one side, colorimetric systems allow for easy read-out by any kind of user, including the consumers. On the other, the continuous advances in printed electronics via the deposition of conductive inks on various substrates are expected to favor the integration of intelligent sensors in packaging materials Nevertheless, it is noteworthy that the lack of standardized and comprehensive toxicity evaluation methods, as well as the often limited stability of the so far developed sensors that could generate the migration of substances in the food products, has generated confused and frequently inconsistent data as far as health and safety concerns are considered. Thus, this poses a challenge in the large-scale fabrication and use of intelligent packages. Hence, the development and validation of standardized tests concerning the safety of future intelligent packages represents one of the main issues to be addressed before their effective large- scale usability. Moreover, it is critical to ensure that intelligent packaging is sustainable in terms of application, design, and production. This is vital not only to improve the management of the food supply chain, but also to reduce global food waste and environmental pollution specifically; the growing environmental burden related to petroleum-derived plastics imposes the enrichment of packaging products with eco-friendly features. However, to date, intelligent devices such as colorimetric and optical tags and especially RFDI and sensors are often not yet designed in respect of recyclability and/or sustainability mechanisms, since their main purpose is to improve food shelf-life by being as cheap and functional as possible. Hence, naturally occurring polymers based on renewable resources, such as cellulose and chitosan, may represents considerable areas of innovation and exciting opportunities for the inexpensive, safe, and sustainable fabrication of eco-friendly intelligent packaging materials.

REFERENCES:

1. Food safety. Available online:https://www.who.int/news-room/fact-sheets/detail/food-safety(accessed on 16 February 2021).
2. Estimating the Burden of Foodborne Diseases. Available online: https://www.who.int/activities/estimating-the-burden-of- foodborne-diseases (accessed on 5 March 2021).
3. Kotsanopoulos, K.V.; Arvanitoyannis, I.S. The Role of Auditing, Food Safety, and Food Quality Standards in the Food Industry: A Review. Compr. Rev. Food Sci. Food Saf. **2017**, 16, 760–775. [CrossRef] [PubMed]
4. Zhou, L.; Zhang, C.; Liu, F.; Qiu, Z.; He, Y. Application of Deep Learning in Food: A Review. Compr. Rev. Food Sci. Food Saf. **2019**, 18, 1793–1811. [CrossRef] [PubMed]
5. Ali, M.H.; Zhan, Y.; Alam, S.S.; Tse, Y.K.; Tan, K.H. Food supply chain integrity: The need to go beyond certification. Ind. Manag. Data Syst. **2017**, 117, 1589–1611. [CrossRef]
6. Callao, M.P.; Ruisánchez, I. An overview of multivariate qualitative methods for food fraud detection. Food Control **2018**, 86, 283–293.. [CrossRef]
7. Yousefi, H.; Su, H.M.; Imani, S.M.; Alkhaldi, K.; Filipe, C.D.; Didar, T.F. Intelligent Food Packaging: A Review of Smart Sensing Technologies for Monitoring Food Quality. ACS Sens. **2019**, 4, 808–821. [CrossRef]
8. Schaefer, D.; Cheung, W.M. Smart Packaging: Opportunities and Challenges. Procedia CIRP **2018**, 72, 1022–1027. [CrossRef]
9. Chen, S.; Brahma, S.; Mackay, J.; Cao, C.; Aliakbarian, B. The role of smart packaging system in food supply chain. J. Food Sci. **2020**, 85, 517–525. . [CrossRef] [PubMed]
10. Jalali, A.; Seiiedlou, S.; Linke, M.; Mahajan, P. A comprehensive simulation program for modified atmosphere and humidity packaging (MAHP) of fresh fruits and vegetables. J. Food Eng. **2017**, 206, 88–97. [CrossRef]
11. Realini, C.E.; Marcos, B. Active and intelligent packaging systems for a modern society. *Meat Sci.* **2014**, *98*, 404–419. [CrossRef] [PubMed]
12. Ghaani, M.; Cozzolino, C.A.; Castelli, G.; Farris, S. An overview of the intelligent packaging technologies in the food sector. *Trends Food Sci. Technol.* **2016**, *51*, 1–11. [CrossRef]
13. Poyatos-Racionero, E.; Ros-Lis, J.V.; Vivancos, J.-L.; Martines-Manez, R. Recent advances on intelligent packaging as tools to reduce food waste. *J. Clean. Prod.* **2018**, *172*, 3398–3409. [CrossRef]
14. Sohail, M.; Sun, D.-W.; Zhu, Z. Recent developments in intelligent packaging for enhancing food quality and safety. *Crit. Rev. Food Sci. Nutr.* **2018**, 1–13. . [CrossRef] [PubMed]
15. Kuswandi, B.; Wicaksono, Y.; Jayus; Abdullah, A.; Heng, L.Y.; Ahmad, M. Smart packaging: Sensors for monitoring of food quality and safety. *Sens. Instrum. Food Qual. Saf.* **2011**, *5*, 137–146. [CrossRef]