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Advance Innovations in the Field of Food Packaging – A Review

M. Kanwal[a], R. Ashraf[b*], A. Jabbar[c], M. Shakir[d], M. Ameeq[e], U. Mushtaq[a] and A. Sarwar[a]

[a] School of Chemistry, University of the Punjab, Lahore, Pakistan

[b] Department of Polymer and Process Engineering, University of Engineering and Technology, Lahore, Pakistan

[c] Bureau Veritas, Lahore, Pakistan (Pvt) Ltd.

[d] Department of Fisheries and Aquaculture, University of Veterinary and Animal Sciences Lahore, Pakistan

[e] Sapphire Textile Mills Limited, Tricon Corporate Centre, Lahore, Pakistan

Abstract

Any packaging used for fresh muscle meals aims to prevent or delay undesirable alterations to the food's texture, flavour, appearance, and odour. If consumers reject the edible products due to these degrading qualities, there may be a financial loss. In an ideal world, a preservative package would not interfere with or impede beneficial enzyme activities to prevent undesirable enzyme activities. As non-enzymatic activities often change the organoleptic qualities of raw meats, preservative packing should ideally slow down or prevent them. Worldwide food consumption rises because of population growth, which expands the global market for packaging materials. The evolving needs of food packaging will be met in part by improvements in food packaging. This article focuses on applications of active and intelligent packaging strategies for fruit storage in the food industry. Meat, non-meat, and marine food packaging is not only a creative technique to enclose or wrap a food product; it also provides a little amount of protection against food deterioration. Packaging should assist in maintaining a product's quality during storage, transit, and deterioration even though it might not improve the quality at present. Especially the flexible packaging, which is expertly designed to fulfil a multitude of purposes to supply us with food in a convenient, safe, and enticing manner. Side-by-side active packaging is a technology that increases safety. The creation of environmentally friendly packaging materials based on biopolymers has been the subject of numerous recent studies. Additionally, because they have the capacity to transport various active substances, biopolymers can be categorized as active packaging materials. The most recent information on the use of biopolymers in packaging materials is presented in this review.

Keywords: Antimicrobial, Antioxidant, Food Packaging, Food Safety, Nanotechnology

1. Introduction

1.1. History of packaging development

For humans to survive, food has needed to be packaged and stored. For thousands of years, a variety of materials, including glass, wood, and earthenware, have been utilized for packaging. The packing of consumer items was not a precise science in the late nineteenth century. Every packaging item the vendor owned was utilized. Grain or sugar and meat wrapping were the two

*Corresponding author: rakhshanda.shah0@gmail.com

most popular uses for newspaper and cloth bags. Thanks to the paperboard box, several products were mass-marketed. Early in the 1800s, Napoleon developed canning to extend the shelf life of food to provide his soldiers with higher-quality meals. But for the past 200 years, steel and steel with a tin coating have only been employed to retain and preserve food [1]. Plastics have only recently been made usable in the food business thanks to the development of mineral oil fractionation. In contrast to rigid containers, plastics are lightweight, frequently transparent, and these days may be produced to approximate some hard container qualities [2]. Self-service store development was encouraged by packaging that created "windows" in paper boxes so that products may be presented in an enticing way. It was during World War II that polyethylene plastic was initially invented. Paper, glass, and steel containers were mostly supplanted by plastics in packaging during the 1950s plastics renaissance. There are several advantages to using plastic containers: they are less expensive, simpler to make, lighter, more durable, and less expensive to ship [3].

1.2. Development in packaging

Long beyond its original function as a means of product preservation, packaging now plays a critical role in marketing initiatives such as enhancing product details, creating on-shelf appeal, and cultivating brand identification and expertise. Consumer demand influenced by shifting global trends like an increasing life expectation of the food product, fewer companies investing in better food production systems. Food packaging utilization is a socioeconomic indicator of the gross domestic product (GDP) and the availability of food in both rural and urban areas. Between 55% and 65% of the $130 billion worth of packaging sold in the USA is used for food and beverages [4]. Some pairings are heat-proof, while others may be used in microwave ovens. Consumers can quickly cook dishes with many components by using packages that are self-heating or have two or three components that each perform a somewhat different function (e.g. ice cream and hot chocolate sauce at the point of consumption). Food manufacturers are now able to satisfy the packaging standards listed below because of the wide variety of materials that are currently accessible. However, the needed shelf life of the product and its chemical makeup must be taken into consideration since each aspect is interconnected. The nutritional content of the packaging component, control (profitability), uniformity, brand reputation, customer expectations, and consumer convenience are additional considerations that come into play. It should safeguard against contamination, uphold food quality standards, local and international laws, and ensure uniformity of product (Figure 1).

1.3. The importance of packaging in the field of food

The purpose of packing is to secure and preserve goods from outside contamination [4, 5]. This includes delaying deterioration, lengthening the shelf life of food that has been preserved, and maintaining the standard and cleanliness of packaged goods. Food is protected from the elements by packing, which includes heat, sunshine, moisture, air pressure, enzymes, artificial fragrances, bacteria, insects, dirt, and airborne particulates, fumes from burning, etc. Lesser functions that are growing more and more important are traceability, tamper detection, and portion control. It's a well-known and successful method of food packaging in modified settings. Carbon and nitrogen dioxide were the only gases used in the initial processing and packaging of goods like cheese and coffee, among other things. The principal gases utilised in this method for the changed

*Corresponding author: rakhshanda.shah0@gmail.com

atmospheric packing are nitrogen, carbon dioxide, and oxygen. CO, He, and Ar, along with a few additional gases, have been designated for MAP by the European Community. Theoretically, MAP was made possible by customer requests. People want food that is enticing, delicious, and fresh always and in any location.

Figure 1: Active packing of the food products in different types of packing.

To fulfil these requirements, the merchant needs to resolve certain major logistical problems. Excellent product stability is required for long-distance shipping. In it to be bought, the food must also seem sufficiently good. Reliability in terms of taste, freshness, and other aspects is crucial for building a devoted customer base. Regulated environment packaging is a method to manage food quality. In this method, the atmosphere of the food is continually monitored to control the changes. Essentially, it involves regulating the temperature, humidity, carbon dioxide content, oxygen content, and so forth. To properly seal a package, hoover packing requires removing all the air from it. Oxygen in the packaging has several detrimental consequences, such as the oxidation of pigments, vitamins E, C, and β-carotene, as well as the proliferation of aerobic micro-flora, particularly moulds. Because of this, eliminating of the O_2 from the media can prevent the growth of micro-organism that all lead to food degradation [6]. The advancements in intelligent and active packaging will be discussed with a focus on various techniques [7].

1.3.1. Meat and meat products packing

Meat is used in a lot of product it is preserved at refrigerated conditions that controls contamination, delayed spoilage, bacterial growth and reduces the weight loss of meat [8, 9]. The purpose of packing meat products is to preserve and maintain the flavor, color, and the odor of the product. Meat can be stored in packages with modified atmospheres that have high levels of oxygen and carbon dioxide (80% O_2:20% CO_2) and maintain acceptable fresh meat color while carbon dioxide inhibits the growth of spoilage bacteria. Meat can also be stored in trays and wrapped in oxygen-permeable packaging. Typically, cooked meats are kept in a 70% N_2:30% CO environment [10, 11]. To balance out the quantities of the other gases or to keep the pack in form, nitrogen is employed as an inert filler gas [12]. Low residual oxygen levels in cooked meat products encourage color denaturation, which gives the surface of the meat a dull grey

*Corresponding author: rakhshanda.shah0@gmail.com

appearance [13]. Oxygen scavengers are used to commercially address this problem. "Active packaging components" comprise a variety of things.

To solve this issue commercially, oxygen scavengers are utilized. Entities referred to as "active packaging components" include oxygen scavengers. Active packaging and intelligent packaging are two general categories under the phrase "smart packaging." According to the definition of active packing, this type of packaging "changes the state of the packed food to increase shelf life or to enhance safety or sensory attributes, while retaining the quality of the packaged food." Intelligent packaging solutions are made to keep an eye on certain characteristics of the food or environment inside the pack and report back on the product's quality or safety. To take advantage of the potential offered by active and intelligent packaging systems, a wide range of technologies have already been created and commercialized.

1.3.2. Packing of sea food

A considerable number of fish are both farmed and wild caught in the seafood sector, which makes it distinct from other food production [5]. Fish quality is a complicated term that depends on a wide range of variables, including freshness (the most essential component), geographic location, cultural context, sexual maturity, dietary preferences, depth of living conditions, and fishing grounds. Certain physical characteristics, such as species, size, look, smell, color, and flavor, directly affect customers [6]. Seafood is often accessible throughout the year; however current study indicates that the freshness of fish and seafood depends on sensory evaluation. At fish auctions, a trained panel of assessors rates the texture, odor, look (eyes, skin, and gills), and color to check the shelf life. Quality Index Method is a grading system developed using the features of several common European fish species, is based on these values [7, 8].

1.3.3. Packing of vegetables and fruits

Wooden crates continue to be widely used as a protective outer packaging for bottles and other sensitive objects, and their use in single-use field boxes is on the rise. They continue to be widely used for beer, wine, and tea. Wooden chests are stackable and have a good impact resistance. They are also reasonably priced. Wood is no longer preferred as a container since high impact resistant plastic crates may be reused again.

1.4. Spoilage of meat

Meat is mostly colonized by aerobic bacteria from the air, which subsequently attack nitrogen-containing substances like amino acids. As amino acids are essentially present in the meat, we must protect amino groups from bacterial attack. The ultimate consequence of the microbial development will be malodorous amines and sulphur compounds, which generate a "odd" odor and flavor that is most commonly referred to as rotten [14]. The impact on public health relies on the type of microbe and how much of it is present in food. A microorganism’s content in food item will predict whether microbial degradation will result in illness. If levels exceed 105 cfu/g at any point during the life of a food, there is a danger that enough enterotoxin will persist in the packaged food to cause illness, irrespective of successive reclaimable levels of the organism. By keeping the temperature consistent throughout the whole chain, fresh meat may be kept frozen [15]. When the flesh is held between -1.5 and +7 °C the whole time after the post-mortem procedure, it is regarded as cold.

1.5. Spoilage of sea food

The primary indication of loss in fish flesh, which is predominantly produced by autolytic alterations, is the enzymatic digestion and destruction of meat [16, 17]. The research of freshness, on the other hand, frequently relates to the development of spoiling bacteria (Pseudomonas spp.,

*Corresponding author: rakhshanda.shah0@gmail.com

Shewanella putrefactions, and photo bacterium phosphorous) that result in the formation of off-odors and off-flavors. However, it is crucial to remember that tissue oxidation and lipids also produces unpleasant flavors and odors (rancidity in oily fish) [16]. Unquestionably, the most prevalent indicator of seafood freshness is odor. The subsequent processing procedures (fresh or frozen, whole or filleted, lose or prepackaged), as well as the kind of packing, will determine the characteristics of packaged seafood (modified atmosphere, vacuum or air) [18]. The microorganisms on the skin and gills steadily rises after death and during preservation, and they disperse throughout the different tissues. According to the environment and the makeup of the product, one or more species of specialized spoilage organisms will often outgrow the others, emitting a variety of breakdown and metabolic chemicals [19].

2. Modification of food packing

2.1. Packaging of meat

For long-term storage, product protection, and preservation, food packaging is essential. These standards are still required to preserve the handling and caliber of food goods. While processing meat products, a variety of factors are taken into consideration, such as color, dryness, lipid oxidation, and fragrance loss.

2.2. Types of packing materials

Flexible packaging (plastic films, paper, aluminum foil), semi-rigid packaging (PET, paperboard/cardboard, Al, PVC containers), and rigid packaging (glass and fiber board containers and crates) are the three categories of materials. Cellophane was the first commercially accessible natural plastic film at the time. It was created from bleached pulp that was sequentially treated with acid and alkali before being plasticized to make the film. At the commercial level, numerous sorts of films are used to wrap the material.

2.2.1. Polyethylene

The most often used type of plastic film that is still freely accessible today is polyethylene. High density polyethylene (HDPE) may be produced at comparable low air pressure and temperature, whereas low density polyethylene (LDPE) requires high atmospheric pressure and temperature for production. Low density polyethylene (LDPE) film possesses a wide range of properties, including great flexibility, transparency to transparency, low water vapor permeability, and moderately high permeability to oxygen, carbon dioxide, and smells. HDPE is better than LDPE due to having least permeability to gases and water content and is translucent to opaque.

2.2.2. Polypropylene

Another type of plastic film that is widely used in food packaging. It has strong flex strength and resistance, as well as a beautiful gloss. It melts at 150 °C and has the ability to pack eatable goods that have high temperature. Occasionally, it is used in meat packaging and raw beef items. The film has low water vapor permeability and is easily heat sealable. It also has high oil and grease resistance. It is also utilized in the production of laminates.

2.2.3. Polyamide

Polyamide, often known as Nylon film, is an inert, heat-resistant material with outstanding mechanical qualities. Nylon-6 is a tasteless and odorless film, making it perfect for packaging fresh and processed goods. Steam can be used to sanitize it. It is used to create laminates with high impermeability and low permeability.

2.3. Active and intelligent packaging

*Corresponding author: rakhshanda.shah0@gmail.com

Producers confront the challenge of producing fine food with a long shelf life that is necessary for customer health. To safeguard the product and extend its stability, advanced packaging solutions have been created. These are referred to as dynamic packaging and smart packaging.

2.4. Active packaging

The shelf life of food stuff can be increased by eliminating the active compounds from food or its surroundings. Improved safety, sensory attributes, and preservation of product quality are the outcomes of these actions [20]. In contrast to traditional packaging, active packaging plays a dynamic function in food preservation. Active packaging technology can be used to control perm-selectivity, or the preferential permeability of packaging components to different gases. Coating, lamination and co extrusion methods are used to adapt perm-selectivity from all now these postharvest technologies is expanding these days. ClO_2 and C_2H_2 humidity packets were the active packaging technologies that were examined. Four sets of samples were examined for their qualitative characteristics over a three-week period at 4 °C. The groups under investigation included normal, active packaging devoid of ClO_2 treatments, active packaging with low and dosage 5 and 10 ppm, respectively ClO_2 treatments. The following variables were measured: gas concentrations, pH, titratable, acidity, total soluble solid content, and color. The most effective method for maintaining (L) brightness and acidity [21].

2.5. Modified atmospheric packaging (MAP)

The main premise of MAP is the removal of oxygen by using modified film or by altering the atmospheric environment that surrounds the meat or meat stuffs. In the event of clostridia, temperature misuse of MAP compounds is essential [22, 23]. Most C. botulinum proteolytic strains do not develop below 10.8 °C. Non-proteolytic strains, on the other hand, may thrive at temperatures as low as 3.380 °C. It has been observed that the lowest temperature for C. botulism type E growth and toxin generation is 3.380 °C.

The food sausages and the sandwiches having infected by *C. botulinum* when held at lower temperatures failed to poisonous for 2 months, however at 260 °C, its toxicity increase in aerobically and anaerobically stored food stuffs after 6 days and 4 days, respectively. When harmful, anaerobic samples were regarded organoleptic ally acceptable, but aerobic samples were not [24]. These findings imply that even short-term thermal abuse cannot be compensated for by employing a CO_2-containing environment. MAP and vacuum packing are two popular meat packaging technologies [24]. Thermoformed base trays for MAP applications may be made of un-plasticized PVC, polystyrene/ethylene/vinyl alcohol, or poly(ethylene terephthalate)/ethylene, whereas preformed base trays are frequently made of poly(ethylene terephthalate).

2.6. Vacuum packaging

The definition of vacuum packing is "material of product that has barrier package from air and evacuated to avert the development of microbes that develop spoilage of food item. " Vacuum packing and packing in a 100% CO_2 modified environment will considerably prolong storage life. The formation of undesirable flavors produced by oxidative rancidity of fat generally limits life of food product [25]. Fresh meat that has been vacuum-packed has a longer shelf life, which enhances marketing and distribution effectiveness. Fresh meat often develops a brown hue before bad germs start to grow. Concerns about meat decomposition are lessened when pH of packed meat is corrected, and optimum temperatures are precisely maintained. Due to bacteria that might grow in the lack of oxygen at these temperatures, meat may still degrade even when refrigerated at the proper temperatures [26].

2.7. Antimicrobial packaging

*Corresponding author: rakhshanda.shah0@gmail.com

Foods with microbial contamination have a shorter shelf life and higher chance of food borne illnesses [27]. Thermal processing, drying, freezing, refrigeration, irradiation, packaging under a changed atmosphere, and adding antimicrobial chemicals or salts are outdated methods of food preservation that have an adverse effect on the growth of microbes. Lysozyme immobilized on several kinds of polymers was examined by Appendini and Hotchkiss (1997) for effectiveness. The most effective example is cellulose triacetate, which contains lysozyme and has the highest level of antibacterial activity. Active food packaging, especially for meat items, benefits from antimicrobial packaging. It has been tried to increase the safety and postpone spoilage by using the antibacterial spray [28].

2.8. Antimicrobials agents

Antimicrobials agents in the food packaging techniques are used to improve preserving safety of food via lowering the contamination at surface of processed food; which not a replacement for proper hygiene method [29]. By prolonging the latent phase of bacteria or inactivating them, antimicrobials lower the growth rate of microorganisms. Antimicrobial agents can be utilized as vapors or directly incorporated into packing materials for gradual release to the food surface. The following substances are being studied for their antibacterial properties [30]:

• Silver ions: Silver salts react when they meet an object, although it moves slowly and reacts more favorably with organic materials. At least one product has already been developed, although research on this is an interesting topic now these days. According to claims, the polypropylene base material of Fresher Longer TM storage packs contains Ag nanoparticles incorporated into it to hinder the growth of bacteria.

• Ethyl alcohol: The secondary odor is left by the evaporation of EtOH adsorbed on SiO_2, which is relatively effective. There are also many other organic acids that are used to store the foods stuffs e.g. propionic, acetic, benzoic, tartaric and lactic [31].

• Nisin: The nisin-coated films were kept at 4 °C and room temperature for 12 weeks while being analyzed weekly. An inhibitory zone experiment was used to evaluate the antimicrobial activity of the various nisin-coated films against Listeria mono-cytogeneses ATCC 19115 and *Lacto coccus* lactic subsp. *cremoris* ATCC 14365. Lactic acid and Gram-positive bacteria have been determined to be the targets of nisin's greatest effectiveness. It works by integrating into target cells' cytoplasmic membranes, and it works best in an acidic environment [29].

• Allyl isothiocyanate: Wasabi, mustard, and horseradish all contain allyl isothiocyanate, which is a powerful antibacterial and antimycotic with a broad spectrum of activity. However, it negatively affects the odour effects in food.

• Essential oils: Studies on the antibacterial benefits of essential oils derived from spices, such as mustard oil in bread and oregano oil in meat are used to preserve the food items [32].

• Oxides of various metals: Antimicrobial compounds for use in food packaging at nano-scale of metal oxides like ZnO and MgO are being investigated [33].

2.9. Intelligent packaging

The foundation of the intelligent packaging material is comprised of devices that can recognize, measure, and report the changes in atmosphere inside the food packed package that are as follow:

2.9.1. Time-temperature indicators

Visible indicators and the radio frequency identification (RFID) tags are different forms to identify food quality. According to increasing exposure of temperature, the visual indicator's change its colors. Enzymatic processes, polymerization, or chemical diffusion are a few of the main modes of action. It is used to ensure, that the food item is delivering to the customer in its best condition, these items serve as a quality indicator for the producer to monitor the exposure of inappropriate

*Corresponding author: rakhshanda.shah0@gmail.com

temperature throughout the transportation and the storage of item. RFID tags are used to monitor the product. Right now, it is employed for tracking live stocks and pricey goods. To read data from an RFID tag, a reader typically sends out a radio signal. After that, a computer is used to analyses the data. A microchip and a small antenna are both inside RFID tags. This makes it possible to read tags from a distance of up to 100 feet for more expensive tags and 15 feet for less expensive ones [34].

2.9.2. 3-MTM monitor mark

The latest two versions of the 3MTM Monitor Mark are available in the market as a threshold indicator for industry, which is meant for monitoring the distribution, and the smart label, which is meant for providing consumer information. The indicator forms by a reservoir pad containing the blue dye and its core are a porous wick layer. At the activation stage reservoir is removed, and a film strip is used to detach the wick from it. A porous wick is available in the market on which a white color is visible. The indicating substance starts melting and diffuses by the porous wick on the exposure to the temperature higher than the critical temperature, which results in the appearance of a blue coloration. With critical temperatures ranging from -15 to 26 °C, indicators are readily available. When exposed to temperatures above those advised for storage, the color of the consumer label, which acts as a partial history integrator, changes. When exposed to temperatures above those advised for storage, the color of the consumer label, which acts as a partial history integrator, changes. As stated above, a dye's melting and diffusion form the basis of the functioning concept [35].

2.9.3. The color altering beverage lids

In the storage of beverages, smart lids are used to have a color-changing ingredient that enables it to transform from bean brown to a brilliant red on the exposure to the heat. Customers are warned in this way that liquid coffee in cup is hotter to drink if the red color is too bright. The brown color will not be dispersed uniformly if the lid is cocked and is improperly positioned, which will signal that there is a chance of leakage. At 38 °C, the color begins to shift and at 45 °C, it reaches its peak intensity. This color-changing additive is acceptable for use on surfaces that come into touch with food because it complies with FDA standards on direct food contact.

2.9.4. Seal and leak indicators

A food product's activity and leak can be determined by. O_2 and CO_2 can check the efficacy of oxygen absorbers and monitor the quality of food. As a result of chemical or enzymatic interactions, the majority of O_2 or CO_2 indicators change color. When the oxygen level surpasses the set limit in a sealed food package, a color shift is visible. The fact that these markers must be stored anaerobically due to their rapid degradation in air is a significant issue with them [36].

2.9.5. Freshness indicators

Freshness is the key factor for determining how quickly packaged foods lose their freshness [37]. As food ages, many volatile metabolites such as, hydrogen sulphide, and ammonia are formed [38]. Changes in the content of hydrogen sulphide or organic acids during storage have been proposed as useful markers of the synthesis of metabolites in meat products, fruits, and vegetables [39]. To detect microbial metabolites and ripeness, markers based on color changes brought on by pH changes have a lot of potential [40]. For determining the freshness of meat and stored fish, carbon dioxide, and hydrogen sulphide, products of microbial development, have tremendous potential. By turning food that contains protein into amino, biogenic amines are

*Corresponding author: rakhshanda.shah0@gmail.com

created. Biogenic amines, then, are merely a loosely-defined sign for the freshness of the meat and preserved fish, and instead represent a marker of food deterioration [41].

2.10. Nanotechnology in packaging

Silicate nanoparticle-enhanced hybrid packaging films have also been created. These coverings shield the food from the moisture content and oxygen supply from the environment while preventing drying. The new organizations in the field of food technologies are examining how nanotechnology can enhance sensitivity or make it easier to detect food poisoning. Agro Micron has created a "Nano-Bioluminescence Detection Spray" which has a luminous protein that is designed to bind this with the surface of microorganisms present preferably in the food. Food and drink contamination can be easily detected thanks to the bright light it creates when bonded. The level of bacterial contamination increases with increasing light intensity [42, 43]. Fresh strawberries were preserved at 4 °C using a unique packaging stuff that is made of polyethylene polymer along the nano-powders of Ag and TiO_2. More slowly than usual, the degradation rate was in nano-packaging. In comparison to standard polyethylene packing, after 12 days of storage, there was a considerable inhibition of the content drop of total soluble solids, titratable acidity, and ascorbic acid. Compared to standard packing materials, nano packaging had less anthocyanin [44].

3. Conclusions

Since the 18th century, when the food business was first introduced to packaging, there have been significant advancements in this field, with the last century seeing many of the smart and intelligent inventions for preserving food. These innovations have raised the quality and safety of food. Consumers and manufacturers alike have benefited greatly from the most recent advancements in packaging technology. Improved storage and preservation techniques are required to increase the competitiveness and expansion of the meat, vegetable, and seafood markets, as well as to produce goods that meet appropriate quality requirements, have a long shelf life, and are well-liked by consumers. By more accurately estimating the best-before dates, smart packaging can reduce waste by providing real-time information on the safety and freshness of pre-packaged seafood. Certain technologies, like TTI and MAP, are already in use and are compatible and complimentary, others, such as RFID, have the potential to be effective but are currently too expensive to be used on individual retail-size pack packets. These are for low-cost sensing devices that are placed near packaged food or its headspace and may provide a precise visual indicator of the food's quality and safety is therefore being driven by current trends. The new methods like delayed oxidation of food items, managing moisture content and controlling microbial development have been the main goals of recent innovations. The packaging industry could be significantly impacted by nanotechnology. Pathogen identification and active packaging are examples of nano-scale developments that are ready to raise the bar for food packaging to new heights. It is necessary to create scavengers that can react quickly, create packaging materials that are toxic-free, biodegradable, or edible and are safe for both people and the environment, and do more research into the rules that govern the evaluation and application of these technologies globally. The innovations in the field of food packaging research by the creation of the 3MTM Monitor-Mark indication, freshness indicators, color indicator, and many more indicators of this type have been created and used extensively.

References

[1]. S. Blunden and T. Wallace, "Tin in canned food: a review and understanding of occurrence and effect," *Food Chem Toxicol,* 41 (2003), 1651-1662.

*Corresponding author: rakhshanda.shah0@gmail.com

[2]. S. J. Risch, "Food packaging history and innovations," *J Agric Food Chem,* 57 (2009), 8089-8092.

[3]. J. H. Han et al., *Intelligent packaging in Innovations in Food Packaging," (Academic Press, Copy right: Elsevier,* 2005)*,* 138-155.

[4]. A. L. Brody, "Packaging by the numbers," *Food Technol,* 62(2) *(*2008), 89-91.

[5]. A. Fazio et al., "Novel acrylic polymers for food packaging: Synthesis and antioxidant properties," *Food Packag Shelf Life,* 11 (2017), 84-90.

[6]. G. H. Zhou, X. L. Xu, and Y. Liu, "Preservation technologies for fresh meat–A review," *Meat Sci,* 86 (2010), 119-128.

[7]. K. Marsh and B. Bugusu, "Food packaging—roles, materials, and environmental issues," *J Food Sci,* 72 (2007), R39-R55.

[8]. A. P. Hutton, G. S. Miller, and D. J. Skinner, "The role of supplementary statements with management earnings forecasts," *J Account Res,* 41 (2003), 867-890.

[9]. J. P. Struewing et al., "The risk of cancer associated with specific mutations of BRCA1 and BRCA2 among Ashkenazi Jews," *N Engl J Med,* 336 (1997), 1401-1408.

[10]. M. Smiddy et al., "Use of oxygen sensors for the non-destructive measurement of the oxygen content in modified atmosphere and vacuum packs of cooked chicken patties; impact of oxygen content on lipid oxidation," *Int Food Res J,* 35 (2002), 577-584.

[11]. S. C. Seideman et al., "Factors associated with fresh meat color: a review," *J Food Qual,* 6 (1984), 211-237.

[12]. R. Bell and B. Bourke, "Recent developments in packaging of meat and meat products," *Proceedings of the international developments in process efficiency and quality in the meat industry, (*1996) 99-119,.

[13]. J. K. Møller et al., "Effect of residual oxygen on colour stability during chill storage of sliced, pasteurised ham packaged in modified atmosphere," *Meat Sci,* 54 (2000), 399-405.

[14]. B. C. Husband and S. C. Barrett, "Colonization history and population genetic structure of Eichhornia paniculata in Jamaica," *Hered,* 66 (1991), 287-296.

[15]. H. Wycherley, A. Fleet, and H. Shaw., "Some observations on the origins of large volumes of carbon dioxide accumulations in sedimentary basins," *Mar Pet Geol,* 16 (1999), 489-494.

[16]. T. R. Gormley, "*Chilled foods: the state of the art*," (London; New York: Elsevier Applied Science, 1990).

[17]. L. Gram and H. H. Huss, "Microbiological spoilage of fish and fish products," *Int. J. Food Microbiol,* 33 (1996), 121-137.

[18]. H. H. Huss, P. Dalgaard, and L. Gram*, Microbiology of fish and fish products* in *seafood from producer to consumer, integrated approach to quality.* Proceedings of the International Seafood Conference on the Ocassion of the 25th anniversary of the WEFTA, held in Noordwijkerhout, The Netherlands, 13-16 November 1995 (Amsterdam: Elsevier, 1997), 413-430.

[19]. N. Hamada-Sato et al., "Quality assurance of raw fish based on HACCP concept," *Food Control,* 16 (2005), 301-307.

*Corresponding author: rakhshanda.shah0@gmail.com

[20]. D. Dainelli et al., "Active and intelligent food packaging: legal aspects and safety concerns," *Trends Food Sci Tech,* 19 (2008), S103-S112.

[21]. M. S. Aday and C. Caner, "The applications of 'active packaging and chlorine dioxide' for extended shelf life of fresh strawberries," *Packag Technol Sci,* 24 (2011), 123-136.

[22]. G. Fox et al., "The phylogeny of prokaryotes," *Sci,* 209 (1980), 457-463.

[23]. K. W. McMillin, "Where is MAP going? A review and future potential of modified atmosphere packaging for meat," *Meat Sci,* 80 (2008), 43-65.

[24]. M. Smiddy, D. Papkovsky, and J. Kerry, "Evaluation of oxygen content in commercial modified atmosphere packs (MAP) of processed cooked meats," *Food Res Int,* 35 (2002), 571-575.

[25]. K. Paramasivan and J. A. Moses, "Vacuum packaging of meat," *Food Marketing and Technology, (*2015), 42-43.

[26]. Z. M. Lima et al., "Effect of Tamarindus indica L. and Manihot esculenta extracts on antibiotic-resistant bacteria," *Pharmacognosy Res,* 9 (2017), 195-199.

[27]. M. A. Valero et al., "Relationships between host species and morphometric patterns in Fasciola hepatica adults and eggs from the Northern Bolivian Altiplano hyperendemic region," *Vet. Parasitol,* 102 (2001), 85-100.

[28]. A. Asdagh et al., "Production and characterization of nanocomposite film based on whey protein isolated/copper oxide nanoparticles containing coconut essential oil and paprika extract," *J Polym Environ,* 29 (2021), 335-349.

[29]. C. L. Wilson, *Intelligent and active packaging for fruits and vegetables* (CRC press, 2007).

[30]. K. Cooksey, "Effectiveness of antimicrobial food packaging materials," *Food Addit Contam,* 22 (2005), 980-987.

[31]. D. S. Cha and M. S. Chinnan, "Biopolymer-based antimicrobial packaging: a review," *J Food Sci,* 44 (2004), 223-237.

[32]. K. I. Suhr and P. V. Nielsen, "Inhibition of fungal growth on wheat and rye bread by modified atmosphere packaging and active packaging using volatile mustard essential oil," *J Food Sci,* 70 (2005), M37-M44,.

[33]. A. L. Brody et al., "Scientific status summary-Innovative food packaging solutions," *J Food Sci,* 73 (2008), R107-R116.

[34]. A. Pavelková, "Time temperature indicators as devices intelligent packaging," *Acta Univ Agric Silvic Mendelianae Brun,* 61 (2013), 245-251.

[35]. D. Zagory, "*Ethylene-removing packaging,"* In: Rooney, M.L. (eds) *Active Food Packaging*. (Boston, MA: Springer, 1995), 38-54.

[36]. S. Huang, S. S Gao, and H. Y Yu, "Effect of nano-hydroxyapatite concentration on remineralization of initial enamel lesion *in vitro*," *Biomed Mater,* 4 (2009), 034104.

[37]. A. Nopwinyuwong, S. Trevanich, and P. Suppakul, "Development of a novel colorimetric indicator label for monitoring freshness of intermediate-moisture dessert spoilage," *Talanta,* 81 (2010), 1126-1132.

[38]. M. Smolander et al., "Myoglobin-based indicators for the evaluation of freshness of unmarinated broiler cuts," *Innov Food Sci Emerg Technol,* 3 (2002), 279-288.

*Corresponding author: rakhshanda.shah0@gmail.com

[39]. C. Wanihsuksombat, V. Hongtrakul, and P. Suppakul, "Development and characterization of a prototype of a lactic acid–based time–temperature indicator for monitoring food product quality," *J Food Eng,* 100 (2010), 427-434.

[40]. M. Smolander, Freshness indicators for food packaging in *Smart packaging technologies for fast moving consumer goods, (*John Wiley & Sons, Ltd., 2008), 111-127.

[41]. S. Banerjee et al., "High throughput non-destructive assessment of quality and safety of packaged food products using phosphorescent oxygen sensors," *Trends Food Sci Tech,* 50 (2016), 85-102.

[42]. H. Kour et al., "Advances in food packaging-a review," *Stewart Postharvest Review,* 9 (2013), 1-7.

[43]. M. Z. Ghouri et al., "Nanotechnology: Transformation of agriculture and food security," *Biosci,* 3 (2020), Pages 19.

[44]. F. Yang et al., "Effect of nano-packing on preservation quality of fresh strawberry (Fragaria ananassa Duch. cv Fengxiang) during storage at 4 °C," *J Food Sci,* 75 (2010), C236-C240.

*Corresponding author: rakhshanda.shah0@gmail.com