

A Review of Food Packaging Materials and Active Packaging System

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Abstract

The purpose of this study is to give a brief review of food packaging materials and active packaging systems used in food processing. The purpose of food packaging is to make our lives easier. Food packaging that is effective serves a number of purposes. It functions as a container to hold and transport the food product, as well as a barrier to protect the food from outside contamination such as water, light, odors, bacteria, dust, and mechanical damage, keeping the food's quality. The package may also include barriers to keep the product's moisture content or gas composition consistent. Sensing is followed by adjustment of the environment in the package to improve the microbiological or biochemical quality of the food content. Active packaging systems, which are divided into adsorbing and releasing systems, can be used to extend the shelf life of processed goods. Active packaging is based on either the intrinsic features of the polymer used as a packaging material or the introduction (inclusion, entrapment) of certain chemicals into the polymer.

Keywords: Food, Packaging, Active Packaging System

Introduction

The purpose of food packaging is to make our lives easier. Packaging is required to hold food, protect it from the elements, and provide information to consumers about the food contained within the box. Traditional packaging meets the basic demands of food containment, but advancements in food packaging are both expected and anticipated. Food packaging serves to protect food from microbiological and chemical contamination, as well as air, water vapour, and light. As a result, the type of packaging used plays a vital influence in determining a food's shelf life. Active packaging is more than just a shield against external forces. It has the ability to control and even respond to events occurring within the package [1].

Consumer demand for packaging that is more advanced and imaginative than what is currently available is driving the development of innovative packaging, such as active packaging. New active and intelligent packaging designs are expected to play an increasingly crucial role by providing various and unique solutions for prolonging shelf life, as well as maintaining, improving, and monitoring food quality and safety [2]. Active packaging technologies are designed to lengthen the shelf life of foods and extend the duration

during which they are of high quality. Active packaging technologies involve a physical, chemical, or biological action that alters interactions between a package, product, and/or package headspace to achieve a desired result [3]. The use of appropriate active packaging systems, depending on the requirements of packed food, can greatly prevent food quality deterioration. Physiological mechanisms (respiration of fresh fruits and vegetables), chemical reactions (lipid oxidation), physical processes (dehydration), and microbiological elements are all factors that might affect the shelf life of packaged foods (spoilage by microorganisms). The purpose of this paper is to give a quick overview of food packaging materials and active packaging systems used in food processing.

Food Packaging**The Need of Packaging**

Food packaging that is effective serves a number of purposes. It functions as a container to hold and transport the food product, as well as a barrier to protect the food from outside contamination such as water, light, odors, bacteria, dust, and mechanical damage, keeping the food's quality. The package may also include barriers to keep the product's moisture content or gas composition consistent. Furthermore, convenience is vital in packaging, and the

desire for quick opening, dispensing, and resealing packages that maintain the product's quality until it is completely consumed is growing [4]. The food package must also be communicative in order to facilitate trading, encourage sales, and tell consumers on the contents and nutritional aspects of the product.

Materials in Food Packaging

Paper, plastic, metal, and glass are the most frequent materials used in food packaging. Glass and metal have great barrier characteristics and interact very little with packed food. Plastic materials have nearly the opposite qualities, such as non-ideal barriers and non-inertness, which cause interactions with food. Nonetheless, over the last few decades, the use of plastic materials in packaging has skyrocketed. Plastics are less expensive than other materials, have a lower energy content, and are lighter in weight while still remaining comparably sturdy [4].

In many circumstances, multiple materials are mixed to achieve the package's desired barrier qualities. Foil, various types of plastic, paper, and adhesives are examples of possible layers. Polyethylene, polypropylene, polyethylene terephthalate, polystyrene, polyamide, and ethylene vinyl alcohol are the most common plastics used in food and beverage packaging [5]. After polyvinyl chloride, Polyethylene (PE) is the most commonly produced plastic in the world, and PP is the third most prevalent bulk plastic.

Polyethylene

Low density polyethylene (LDPE), high density polyethylene (HDPE), and linear low-density polyethylene (LLDPE) are the three primary forms of polyethylene, with LDPE being the most common in packaging. PE's mechanical characteristics are determined by its molecular weight and branching degree. Heat sealability, toughness, high elasticity, cold resistance, and superior water vapour resistance are the most essential features of PE in packaging applications. LDPE is a flexible, highly branching plastic that may be made into films, bottles, closures, dispensers, paper or aluminum foil coatings, as well as huge tanks and containers. Because LDPE has a high permeability to gases, smells, and fats, it must be coupled with other materials in several food packaging applications. For example, LDPE alone is ineffective in applications where oxidation is a concern. HDPE is harder and more brittle than LDPE and has better barrier properties. HDPE is used as storage and distribution containers but also as films with high fat resistance for meat and other products [6].

Polypropylene

Polypropylene (PP) has a chemical structure comparable to PE, although it is tougher and less waxy. It comes in the form of films, sheets, trays, and bottles that keep their shape at high temperatures. As a result, they can be sanitized or filled with hot water. PP is resistant to grease and solvents. Other distinguishing characteristics of PP are its resilience to fatigue when flexed and its lack of stress cracking. PP, on the other hand, has a low cold temperature resistance. The gloss, clarity, impact strength, and water and oxy-

gen barrier qualities of biaxially oriented PP films have been enhanced. They're used to wrap a variety of meals, including snacks and biscuits.

Polystyrene

Polystyrene (PS) is a strong, translucent, and water-resistant plastic. Brittleness and sensitivity to stress cracking, as well as high gas and moisture vapour permeability, are the key disadvantages. PS's major applications are in products with short shelf lives, such as yoghurt, ice cream, fresh cheese, and coffee cream, due to the latter feature. However, in recent years, PS has been phased out in favor of the less expensive PP [6].

Polyethylene Terephthalate

Polyethylene terephthalate (PET) is a polyester with high tensile strength (it must be oriented to achieve full tensile strength), good chemical resistance, light weight, flexibility, and temperature stability. Because of its high temperature stability, PET products such as boil-in-bags and oven bags have been developed. Gases, smells, and lipids have good barrier characteristics in PET, although water vapour permeability is slightly higher. Containers for carbonated beverages, culinary oils, and spirits are made of biaxially stretched PET, which is stronger and has a superior gas barrier than unstretched PET. PET coatings of LDPE can be created to increase sealability and toughness. Metallization [7], silica coating, epoxy amine coating, and poly vinyl indene chloride coating of PET can also improve barrier characteristics [8].

Polyamide

There is a large variety of polyamides, commonly called nylons. Since hydrogen bonds are formed between the molecules, PA is hard, temperature resistant and some types have high crystallinity. The melting point of PA is between 177-255oC and it can be used at low temperatures ranging from -50oC to -70oC. Further, PA is a good gas barrier while the barrier properties to water are not so good. However, PA is rather expensive and the main application is in laminates with for example Polyamide (PE). PE gives good water resistance and heat salability. These laminates are for example used for vacuum or inert gas packed meat products, fish and cheeses. Biaxial stretching of PA improves stiffness of the material and is used as carrier film in laminate packages for stiffer vacuum or inert gas packing of coffee, milk powder and meat products as well as for "bag-in-box" liquid packages.

Ethylene Vinyl Alcohol

EVOH is a plastic with exceptional barrier properties which is manufactured by saponification of the ethylene vinyl acetate copolymer. Under dry conditions EVOH has excellent oxygen barrier properties but is inherently moisture sensitive and becomes permeable when absorbing moisture. This is a big problem during sterilization and EVOH is therefore used as barrier material in multi-layer constructions with for example PE. [9]. EVOH has also been an excellent flavour barrier in contrast to other plastic materials, which may scalp desirable aromas from the food product. Therefore, EVOH is also used as a barrier against flavour loss.

Driving Forces for New Concepts in Packaging

New developments in food packaging are underway and the main driving forces for these changes include consumer demands, industrial competition and regulatory aspects. Environmental concern and efforts to decrease the solid waste stream are crucial. The requirements from the consumers include mildly preserved, high quality convenience food as well as greater assurance of food safety and better information of the food product [5,10].

The globalization of the food industry demands products with longer shelf life and lighter weight materials. To address these needs, research is ongoing to improve barrier properties of the packaging as well as develop new concepts such as active and intelligent packaging. Barrier properties of the package has been improved by combining different materials as foil, different kinds of plastic, paper and adhesives through lamination, coextrusion or coating [5,10].

Active Packaging System

The integration of certain materials into packaging for the purpose

of maintaining and increasing product shelf life is known as active packaging. Sensing is followed by adjustment of the environment in the package to improve the microbiological or biochemical quality of the food content. Active packaging is based on either the intrinsic features of the polymer employed as a packaging material or the introduction (inclusion, entrapment) of specific compounds inside the polymer. Packaging is considered active when it serves a purpose other than providing an inert barrier to external circumstances in the preservation of food. Active packaging, on the other hand, has been characterized as packaging that “changes the condition of the packed food to increase shelf-life or improve safety or sensory characteristics while maintaining packaged food quality” [11]. It’s only recently that a variety of active packaging solutions have been developed, some of which could be used in both new and existing food products. Active packaging consists of additives or “freshness enhancers” that can be used in a variety of packaging applications to improve the basic packaging system’s preservation function. Some of the food applications that have benefited from active packaging technology (table 1) [12].

Table 1: Selected examples of active packaging systems

Active packaging system	Mechanisms	Food applications
Oxygen scavengers	iron based metal/acid metal (e.g., platinum) catalyst ascorbate/metallic salts enzyme based	bread, cakes, cooked rice, biscuits, pizza, pasta, cheese, cured meats and fish, coffee, snack foods, dried foods and Beverages
Carbon dioxide scavengers/emitters	iron oxide/calcium hydroxide ferrous carbonate/metal halide calcium oxide/activated charcoal ascorbate/sodium bicarbonate	coffee, fresh meats and fish, nuts and other snack food products and sponge cakes
Ethylene scavengers	potassium permanganate activated Carbon activated clays/zeolites	fruit, vegetables and other horticultural products
Preservative releasers/ Antimicrobial agents/	organic acids silver zeolite spice and herb extracts BHA/BHT antioxidants vitamin E antioxidant volatile chlorine dioxide/ sulphur dioxide	cereals, meats, fish, bread, cheese, snack foods, fruit and vegetables
Ethanol emitters	alcohol spray encapsulated etanol	pizza crusts, cakes, bread, biscuits, fish and bakery products
Moisture absorbers	PVA blanket activated clays and minerals silica gel	fish, meats, poultry, snack foods, cereals, dried foods, sandwiches, fruit and vegetables

Flavour/odour adsorbers	cellulose triacetate acetylated paper citric acid ferrous salt/ascorbate activated carbon/clays/zeolites	fruit juices, fried snack foods, fish, cereals, poultry, dairy products and Fruit
Temperature control Packaging	non-woven plastics double walled containers hydrofluorocarbon gas Lime/water ammonium nitrate/water	ready meals, meats, fish, poultry and beverages

Oxygen Scavengers

The presence of O₂ in a packed meal is frequently a determining element in a product's shelf life. Oxidation can change the flavor, color, and odor of food, as well as destroy nutrients and allow aerobic bacteria, molds, and insects to thrive. As a result, food-packaging scientists have long sought to remove O₂ from the package headspace and from the solution in liquid foods and beverages. O₂ scavengers, which remove leftover O₂ after packing, can help to keep the quality of O₂ sensitive products from deteriorating. Materials integrated into package constructions that chemically react with, and so efficiently remove, oxygen from the inside package environment are referred to as oxygen scavengers. As a result of differential partial pressure actions, scavengers may remove oxygen from the food product itself through diffusion. Scavengers are fast-acting, high-capacity oxygen interceptors, capable of removing relatively significant quantities of oxygen and continuing their action forever as long as the scavenger is there. Existing O₂ scavenging technologies use iron powder, ascorbic acid, photo-sensitive dyes, enzymes (such as glucose oxidase and ethanol oxidase), unsaturated fatty acids (such as oleic, linoleic, and linolenic acids), rice extract, or immobilized yeast on a solid substrate to oxidize one or more of the following substances [13].

Advantages Oxygen Scavengers

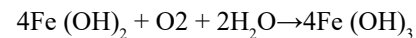
Oxygen scavengers have the following advantages:

- They are an economical and efficient alternative to the use of modified atmosphere and vacuum packaging and they slow down metabolism of food.
- They prevent oxidation phenomena: rancidification of fats and oils and consequent emergence of off-odors and off-flavors, loss or change of colors characteristic of food, loss of oxygen-sensitive nutrients (vitamins A, C, E, unsaturated fatty acids, etc.) [14].
- They prevent the growth of aerobic microorganisms.
- They reduce or eliminate the need for preservatives and antioxidants in food by incorporating the added value of "fresh" or "natural." The use of these systems, either alone or in combination with other traditional packaging systems, and the use of modified atmospheres can therefore extend the commercial life of a food product.

Mechanisms of Action of Oxygen Scavengers

Different mechanisms of action of oxygen scavengers are:

- Oxidation of iron and iron salts: This is the most widely used most effective. Oxygen scavenger systems that are based on iron oxidation reactions are explained by the following equation [15].



This system is based on the oxidation of iron and ferrous salts (provided in the packet) that react with water provided by food to produce a reaction that moisturizes the iron metal in the product packaging and irreversibly converts it to a stable oxide. The iron powder is contained within small oxygen permeable bags that prevent contact with food.

- Oxidation of ascorbic acid and unsaturated fatty acids (oleic, linoleic).
- Oxidation of photosensitive coloring matter.
- Enzymatic oxidation by Glucose oxidase [15].

These methods can reduce oxygen levels to < 0.01%, which is much lower than the typical level of 0.3-3.0% obtained with residual oxygen-modified atmosphere packaging [16]. This lower level of oxygen can be maintained for long periods depending upon the oxygen permeability of the packaging material. The disadvantages of sachets are the need for additional packaging operations to add the sachet to each package, also they cannot be used in beverages or foods containing high levels of water because they become inactive when wet [17]. Also, in high moisture foods aqueous slurry of oxygen absorbent is formed when moisture enters the adsorbent packet. The aqueous slurry oozes out of the package on to the foodstuff, spoiling its appearance [18]. In contrast, ascorbic acid can be used in liquid food or beverage as an efficient oxygen scavenger

Commercial Presentations of Oxygen Scavengers

Commercial presentations of oxygen scavengers are:

- Independent systems such as bags, strips, or labels, which are incorporated into or attached to the inside of the package, but are separate elements. They are the most widely used systems.
- Systems integrated into the packaging material itself, not visually perceptible as distinct elements. Iron, ascorbic acid, and low-molecular-weight ingredients are used in this way [19].

Carbon dioxide Emitters and Scavenger

The presence of high quantities of carbon dioxide in the packaging has an antibacterial impact on the surface of various items, such as meat and poultry, resulting in a longer storage life. However, because carbon dioxide is more permeable through plastics than oxygen, carbon dioxide generation in the packaging may be required in some circumstances to maintain the proper gas composition.

Carbon dioxide adsorption is also used to avoid pressure build-up, swelling, and even bursting of the package of respiring foods, resulting in a reduction in product shelf life. There has been a lot of effort put into reducing the amount of pressure in kimchi packets. (Kimchi, which is made from fermented vegetables such as cabbage and onion and is highly popular in Korea, produces carbon dioxide even when stored in the refrigerator.) Zeolite has been proven to effectively absorb carbon dioxide, leading in reduced kimchi package swelling [20]. Because of the Strecker degradation reaction between sugars and amino acids, there is a lot of carbon dioxide in roasted coffee [21]. Both oxygen and carbon dioxide levels are reduced using a scavenger made of iron powder and CaOH. The decreased carbon dioxide content prevents the packaging from bursting, while the lower oxygen content prevents oxidative flavor alterations. As a result, the shelf life will be increased [21].

Carbon dioxide generators should be used to prevent packages containing oxygen-scavengers from collapsing. The majority of these systems rely on ferrous carbonate or a combination of ascorbic acid and bicarbonate. The most common uses for systems that combine oxygen-absorbers and carbon dioxide emitters are for items that require a large amount of packaging capacity and a pleasing look, such as peanuts and potato crisps [22]. Microbial activity is known to be suppressed by carbon dioxide. CO₂ levels in the range of 60 to 80 percent limit microbial development on surfaces, extending shelf life. As a result, impregnation of a packaging structure with a CO₂ generating device, or the insertion of the latter in the form of a sachet, is a complimentary strategy to O₂ scavenging. Because CO₂ permeability in most plastic films is 3 to 5 times that of O₂, it must be continuously produced to maintain the desired concentration within the package. A CO₂ generator is only suitable in a few applications, such as the packing of fresh meat, poultry, fish, and cheese. In food products where the package volume and attractiveness are important, a CO₂ generator and an O₂ scavenger could be used together [22]. To prevent packaging collapse due to O₂ absorption. Although carbon dioxide has a microbiological inhibitory effect in modified environment packaging, too much of it can have a negative impact on the product or even reverse the inhibitory effect. As a result, several food-preservation packaging technologies are designed to remove CO₂ [23].

Ethylene Scavengers (Ethylene Absorbers and Emitters)

The control of ethylene in stored conditions plays a key role in prolonging the postharvest life of many types of fresh produce [24]. Ethylene is a plant hormone produced during the energy genera-

tion processes in living cells of some fruits. These fruits, which are called climacteric, include apples, avocados, bananas, mangos, pears, kiwis and tomatoes. Non-climacteric fruits include grapes, lemons, oranges, pineapples and strawberries [23].

It has been known for long that even low concentrations of ethylene accelerate ripening of all fruits and vegetables, both climacteric and non-climacteric by stimulating the respiration rate. For example, ethylene is used commercially to ripen bananas and tomatoes as well as to get orange colour on the oranges. By removing ethylene from the surrounding environment of the fruit or vegetable, the respiration rate is slowed resulting in slower ripening and therefore longer shelf life [25]. The control of ethylene in stored conditions plays a key role in prolonging the postharvest life of many types of fresh produce. Most fruits and vegetables release ethylene after they are harvested and it initiates and accelerates ripening, produces softening and degradation of chlorophylls, and inevitably leads to deterioration of fresh or minimally processed fruits and vegetables.

Mechanism of Action:

a. Other systems are based on the ability of certain materials to absorb ethylene, alone or with any oxidizing agent. For example, palladium has been shown to have a higher ethylene adsorption capacity than permanganate-based scavengers in situations of high relative humidity [26]. LDPE and HDPE polyethylene films as packaging material are able to absorb ethylene; ethanol, ethyl acetate, ammonia, and hydrogen sulfide are used in food industry. These films keep food fresh for longer and eliminate odors.

b. One of the main mechanisms of action of ethylene scavengers is based on the use of potassium permanganate, which oxidizes ethylene to carbon dioxide and water. The typical permanganate content is between 4% and 6% [27]. Potassium permanganate oxidizes ethylene and changes color from purple to brown, and thus, a color change indicates its residual ethylene absorbing capacity, but because of its toxicity potassium permanganate cannot be used in direct contact with food.

Ethanol Emitters

Ethanol is used routinely in medical and pharmaceutical packaging applications, indicating its potential as a vapor phase inhibitor. It prevents microbial products. It also reduces the rate of staling and oxidative changes [28]. Ethanol has been shown to extend the shelf life of bread, cake and pizza when sprayed onto product surfaces prior to packaging. Sachets containing encapsulated ethanol release its vapor into the packaging headspace thus maintaining the preservative effect. Those, rate of ethanol vapor release can be tailored by controlling the permeability of the sachet [22].

Moisture Absorbers

Water is produced in respiring foods during the metabolism of fats and carbohydrates and wet food give high water vapour pressure. Condensation is therefore common in many packed foods especially for fruits and vegetables. When there is a temperature differ-

ence within or outside the package, water droplets appear on the packaging walls or cover the food surface. Water droplets on the packaging surface results in worsen package appearance as well as less consumption, while a moisten food surface results in increased surface mold growth and therefore diminished shelf life of the food product. This can be avoided by using a desiccating film or sachet.

Pads filled with propylene glycol or cellulose fibre pads are often used in contact with meat and fish within the packages in order to adsorb water. Currently most work is focused on finding better solutions to incorporate the desiccant within the packaging [29].

Moreover, Excess moisture is a major cause of food spoilage. Soaking up moisture by using various absorbers or desiccants is very effective in maintaining food quality and extending shelf life by inhibiting microbial growth and moisture related degradation of texture and flavor. For packaged dried food applications, desiccants such as silica gel, calcium oxide and activated clays and minerals are typically contained within tear-resistant permeable plastic sachets. For dual-action purposes, these sachets may also contain activated carbon for odour adsorption or iron powder for oxygen scavenging.

Flavour/Odour Absorbers

Further examples of active packaging concepts include removal of unpleasant aromas and flavours. Applications for scavengers of undesirable odours include removal of amines, which are produced under oxidation of protein-rich foods like fish, removal of aldehydes produced by oxidation of fatty acids in biscuits, fried foods and cereals as well as removal of bitter tasting components like limonin in fruit juices [25]. Plenty of work on odour removal by porous pads has been done with products like diapers but the technologies are often applicable to food packaging concepts as well [23].

The removal of odors from the interior of food packages may be both beneficial and detrimental. The issue of the benefits of odor/aroma removal is, however, significant in the realm of active packaging. Many foods such as fresh poultry and cereal products develop what are referred to as confinement odors. Very slight and generally insignificant but nevertheless detectable deterioration odors, such as sulfurous compounds from protein/amino acid breakdown or aldehyde/ketone compounds from lipid oxidation or anaerobic glycolysis, may form during product distribution. These odors are trapped within gas-barrier packaging so, when the package is opened, they are released to be detected by consumers. These relatively harmless odors, which generally do not signal any significant spoilage, may be cause for rejection even though they dissipate into the surrounding air within seconds. One reason for odor removal from the interior of packages would be to obviate the potentially adverse effects of these “confinement odors.” A second reason for incorporating odor removers into packages is to obviate the effects of odors developed in the package materials themselves. During plastic processing, i.e., extrusion, molding,

film and sheet blowing, or casting, some polyolefin components may tend to break down or oxidize into short chain and often odorous hydrocarbon compounds. Antioxidants are often included in the polyolefin-processing additive package to try to minimize the undesirable odor effects [23].

Antimicrobial Agents

Antimicrobials in food have been used for a long time, but antimicrobial interactive packaging is a relatively new approach to control microbial surface contamination of foods. There are both migrating and non-migrating antimicrobial systems. Since both require intensive contact between the food product and the packaging material, the primary applications have been vacuum or skin-packed products [30].

Emission of ethanol in the package environment has been shown to extend the shelf life of bakery products. Ethanol lowers the water activity on the food surface and thereby suppresses the growth of some bacteria, yeasts and moulds. Ethanol has also been shown to have an anti-staling effect on bread.

Food packages can be made AM active by incorporation and immobilization of AM agents or by surface modification and surface coating. Present plans envisage the possible use of naturally derived AM agents in packaging systems for a variety of processed meats, cheeses, and other foods, especially those with relatively smooth product surfaces that come in contact with the inner surface of the package. This solution is becoming increasingly important, as it represents a perceived lower risk to the consumer [31]. Antimicrobial films can be classified in 2 types:

1. Those that contain an AM agent that migrates to the surface of the food, and
2. Those that are effective against surface growth of microorganisms without migration.

Temperature-Controlled Packaging

Temperature regulation Innovative insulating materials, as well as self-heating and self-cooling cans, are all examples of active packaging. Special insulating materials, for example, have been created to protect cold goods from undue temperature abuse during storage and distribution. Thinsulate, a nonwoven plastic with many air pores, is one such material. Another way to keep chilly temperatures is to enhance the thermal mass of the food packaging so that it can resist temperature changes. Self-heating cans and containers have been on the market for decades, and they are especially popular in Japan. An exothermic reaction happens when lime and water positioned in the base are mixed to heat self-heating aluminum and steel cans and containers for sake, coffee, tea, and ready meals [12].

Aroma Release

There are several reasons why it is desirable to release aroma compounds into or outside the packaging. First, addition of pleasant aroma compounds may mask unpleasant and bothering odours but

it may also be a way to avoid flavour scalping by changing the equilibrium conditions. Further reasons include improvement of the consumer appeal of the food product by amending the aroma precipitation when opening the packaging or attracting the consumers by aroma emitting packaging materials. However, currently most aroma-emitting products are applied in plastic products for non-food applications [32].

Further actors in this area are the company Plastiflac, which produce aroma-emitting injection molded plastic products. They add the scent into the plastic melt before injection molding. Vista International Packaging has developed coatings for sausages that contain spices and flavours. Work has also been done on incorporation of aroma compounds into films of silica gel, ethylene vinyl alcohol, polyvinyl chloride etc. However, these films often have poor mechanical flexibility, short fragrance life and cause problems in the plant production environments. At Dow Corning/Felton Polytap a polymer-entrapment system with a hydrophobic thermoset polymeric lattice network has been used to hold fragrance and to get controlled release. Application of this product include antimicrobials and animal repellents [23].

Modified Atmosphere Packaging

There are packaging approaches that not interact with the foodstuff directly, but the adjusted environment within the package increases the shelf life of the packed food product. This concept is called modified atmosphere packaging (MAP). For instance, carbon dioxide is produced and oxygen is consumed during the respiration of fruits and vegetables. By lowering the oxygen content and increasing the carbon dioxide content within the package, the respiration rate and ethylene production of fruits and vegetables are reduced and therefore the shelf life is extended. Research is going on to find the optimal gas composition for each specific fruit, vegetable or other products [21].

Food Safety, Consumer Acceptability and Regulatory Issues of Active Packaging

Food safety and regulatory challenges linked to active packaging of foods must be addressed in at least four ways. Before using any type of active packaging, any necessity for food contact approval must be determined. Second, environmental standards governing active-packaging materials must be considered. Third, in circumstances where active packaging may cause consumer misunderstanding, labeling may be required. Fourth, the impacts of active packaging on food microbial ecology and safety must be considered [33].

Because active packaging can affect foods in two ways, food contact clearance will be required frequently. Active packaging ingredients may migrate into or be eliminated from food. Migrants might be intentional or unintentional. Antioxidants, ethanol, and antimicrobial preservatives are examples of intended migrants that would require regulatory approval in terms of their identification, concentration, and potential toxicological consequences. Various

metal compounds that perform their active purpose inside packaging materials but do not need to, or should not, enter meals are examples of unintended migrants. Any such inadvertent migration must be identified and quantified, according to food additive rules [12]. Environmental standards governing reuse, recycling, and identification of active packaging materials to aid in recycling or energy recovery must be addressed on a case-by-case basis [33].

To avoid the risk of consumers eating the contents of oxygen scavenger sachets or other in-pack active-packaging devices, food labeling is presently required. Some active packages differ from their passive equivalents in appearance. Even in the absence of laws, it may be prudent to employ suitable labeling to clarify this distinction to the consumer. Finally, it is critical for food manufacturers who use specific types of active packaging to evaluate the implications for microbial ecology and food safety. Taking all of the oxygen out of packs of high aw cold perishable food products, for example, may encourage the growth of anaerobic dangerous bacteria such *Clostridium botulinum* [34].

Conclusion

Changes in customer tastes have resulted in new packaging technology advancements and developments. Active packaging technologies provide up new possibilities for the food business in terms of food preservation (Table 1). It's a new and interesting area of food science that has the potential to improve the preservation of a wide range of foods. Because of recent improvements in packaging, material science, and new consumer expectations, active packaging is gaining traction. Active packaging systems, which are divided into adsorbing and releasing systems, can be used to extend the shelf life of processed goods. However, the acceptance and cost-effectiveness of this sort of packaging for business and consumers will determine its development and implementation [35,36].

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