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Recent trend in modified atmospheric packaging: A review

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ABSTRACT
Modified atmosphere packaging is a very common technique in preservation techniques in the food industry.Modified atmosphere packaging is becoming more popular for preserving freshness and extending the storage and shelf life of fresh fruits and vegetables. It may be defined as the enclosure of food products in gas-barrier materials, in which the gaseous environment has been changed. The success of MAP-fresh foods depends on many factors including types of fresh foods, storage temperature and humidity, gas composition, and the characteristics of package materials.So, the innovations and development of food packaging technology will continue to promote the development of novel MAP. This review paper highlighting the recent developments of film and gas on the quality of MAP fresh foods.
Key words – Modified Atmospheric Packaging (MAP), Gas-barrier, Gas composition

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INTRODUCTION

The historical development of modified atmospheric packaging (MAP) are term implying the addition or removal of gases from storage room, transportation containers or packages in order to manipulate the levels of gases such as oxygen, carbon dioxide, nitrogen, ethylene etc; and achieve an atmospheric composition different to that normal air around the food [1] Modification of packaging atmosphere from normal atmosphere (78% nitrogen, 21% oxygen) is widely used as effective modern packaging technologies which can significantly extend shelf life and improve quality level of foods and food products. The composition or condition of the package atmosphere optimal for a food or food product is different with product type, and thus is created in consideration of interaction between atmospheric composition and packaged food.

The demand for fresh and natural products without the addition of dangerous chemicals increased dramatically. MAP seemed to be the ideal method of preservation of many foods, because it could extend the shelf life of the food product significantly, without affecting its fresh or fresh-like characteristics. Nowadays, MAP has become an integral part of the food industry, particularly the fresh produce industry, and it is more important than freezing and canning combined.

The objectives of MAP are to extend the shelf life of food and food products and to prevent any undesirable changes in the wholesomeness, safety, sensory, characteristics and nutritive value of foods. MAP reduces undesirable physiological, chemical/biochemical, physical changes and controls microbial growth. The three main gases used in MAP are nitrogen, oxygen, and carbon dioxide. The role and the importance of each gas in MAP are related to its properties. Nitrogen is an inert gas and tasteless gas, without any antimicrobial activity. It is not soluble in water, and it is primarily used to displace oxygen and prevent package collapse. Oxygen inhibits the growth of anaerobic micro-organism, but promotes the growth of aerobic microbes. Additionally, oxygen is responsible for several undesirable reactions in food, including oxidation and rancidity of fats and oils, rapid repining and senescence of fruits and vegetables, staling of bakery products, color changes and spoilage due to microbial growth. Due to oxygen's negative effects on the preservation of the food quality, it is avoided in the MAP of many products. However, its presence in small quantities is at necessary for some products like fruits, vegetables and red meats. Corban dioxide is soluble in both the water and lipids and its solubility increases with decreasing temperature. The dissolution of carbon dioxide in the product can result in package collapse. Carbon dioxide has a bacteriostatic effect, and it slows down the respiration of many products. All three gases are common and readily available, safe, economical, and are not considered to be chemical additives. There are some other gases like argon, carbon monoxide, ethanol and sulfur dioxide etc. Carbon monoxide inhibits microbial growth and sulfur dioxide used to prevent oxidative browning and to control the growth of bacteria and molds. Ethanol enhances firmness and reduces fungal activity while, argon reduces microbial growth. Modified atmospheric packaging classified in to two types passive modified atmospheric packaging and active modified atmospheric packaging [2]. Active MAP is, when some additives are incorporated into packaging film which modify the headspace atmosphere. These additives have lots of properties like absorbing or scavenging properties, releasing or emitting properties, temperature and microbial control [3].So, additives are help to maintain desirable atmosphere in side package by adjusting the gas composition from the beginning of storage which control the respiration rate of foods and food products.

MAP offers many advantages to consumers and food products; it offers high-quality food products with an extended shelf life. It also reduces or sometimes eliminates chemical preservatives and leading to more natural and healthy products. That's why modified atmospheric packed food products increases their demand in the future.As the year is passing, researchers have discovered many other types of modified atmospheric packaging such as high-oxygen MAP (HO MAP), controlled MAP (CMAP), and intelligent AAP (IMAP) [4].So this paper reviews the recent research progress on different new types of MAP and the applications of MAP in foods and food products.

RECENT DEVELOPMENTS IN GASES USED IN MAP

The main gas mixture used in modified atmospheric packaging usually consist of nitrogen, oxygen, and carbon dioxide, but other gases can be usefully included in the modified atmosphere. Nowadays, some other gases used in MA packaging like as gas oxides (carbon monoxide (CO), nitrous and nitric oxides, sulphur dioxide (SO_2), propylene oxide), ethylene, chlorine, ozone, and noble gases (e.g. He, Ar, Xe and Ne) have been investigated in MAP storage [5, 6]. These gas used singly or in combination to balance the shelf life and organoleptic properties of food and food products.

Carbon dioxide – Carbon dioxide is unique in that it has high solubility in aqueous and fatty foods and antimicrobial activity against aerobic Gram-positive bacteria, mold and some yeast. The proposed to inhibit microbial activity is alteration of cell membrane function on nutrient uptake, direct inhibition of enzymes, intracellular pH change due to penetration of dissolved CO_2 through cell membrane, and direct changes protein properties. The level of dissolved carbon dioxide in foods is known to affect directly the degree of microbial inhibition. The solubility of CO_2 in aqueous foods increases with moisture increase and temperature decrease. Therefore the effectiveness of CO_2 gas in microbial inhibition increases with higher moisture food at lower temperature [7]. Carbon dioxide have one draw that pack collapse due to high solubility. Carbon dioxide causes the pack to collapse due to high solubility.

Carbon monoxide

Carbon monoxide (CO) is not at all a common gas in MAP application, but its possible use deserves some mentioning. Carbon monoxide is a colorless, odorless, and tasteless gas with poisonous and potentially lethal properties. Carbon monoxide bind to myoglobin in the muscles, forming carboxymyoglobin. This product is much more stable than oxymyoglobin and has a bright red-pink color, and therefore the use of small amounts of carbon monoxide in MAP for meat and some fish is really attracting. Moreover, CO is able to inhibit several oxidase enzymatic systems, particularly those including copper like tyrosinase which is responsible for many browning reaction in fruits and vegetables. CO also has antimicrobial activity, particularly against some specific spoilage bacterialike *Brocothrixt hermosphacta*, a common contaminant in meat products [8] CO has been studied in the MAP of meat and has been licensed for use in the USA to prevent browning in packed lettuce. Commercial application has been limited because of its toxicity and the formation of potentially explosive mixtures with air.Because of their toxic nature, its use in the food industry is controversial. Some countries allow the use of CO in food processing such as the U.S., Canada, Australia, and New Zealand, while the European Union states ban it from food processing. The USA has approved 0.4% CO for use in fresh meats [9].

Sulphur dioxide

Sulfur dioxide in the form of nonionized molecular have antimicrobial activity and widely used in grapes storage since the 1960s (10). SO_2 can be released by a small pad which contains sodium metabisulfite [11].Recently new simple SO2 release device is developed e.g. a plastic laminate macro-perforated SO_2 generating pad. This device has an additional water vapor barrier penetration but SO_2 diffusion out of the pad. When SO_2 micro generators combine with CO2 have an active effect on the storage of table grapes by reducing both weight loss and proliferation of *Botrytis cinerea* [12].

Nitrous and nitric oxides

Nitric oxide is a highly reactive gas and has free radicals. It changes the physiological processes of plants by multifunctional signaling molecules (14). Many research showed that nitric oxide delays fruit ripening by decreasing ethylene production. It is also reported that nitric oxide improves the stress-resistant ability and quality of fruit and the postharvest life (13, 14).

Nobel gas

Noble gases are an element of group 18 of the periodic table. This group contains helium, neon, argon, krypton, xenon, and radon. They nonreactive due to their stability. Argon is the most commonly used in MA packaging. Argon is colorless, odorless gas, and more dense to nitrogen. Since it displaces and excluded oxygen more efficiently than nitrogen. It provides better control against oxidation of flavor and color components of foods. Argon is competitive inhibitor of respiratory enzymes, including oxidases [15].

RECENT TREND IN MA PACKAGING FILM AND MATERIALS

A wide range of plastic films and trays are used and most of these are found to be satisfactory. The plastic film may be used to serve the basic packaging functions of containment, protection, communication, and utility in the delivery of quality products to the consumer [16].Film thickness, polymer type, and many other factors that influence the film permeability [17]. Respiration rate of each fruit and vegetables are different and to achieve specific equilibrium atmosphere is dependent on film type and respiration rate of food.The basic component of plastic film is four polymers of polyvinyl chloride (PVC), polyethylene terephthalate (PET), polypropylene (PP) and polyethylene (PE). Some plastic films are often used in MAP like low-density high-density polyethylene (HDPE), polyethylene (LDPE), linear low-density polyethylene (LLDPE), polypropylene(PP), polyvinyl chloride (PVC), polyester, i.e. polyethyleneterephthalate(PET), polyvinylidene chloride (PVDC), polyamide (Nylon) and other suitable films.The choice of packaging materials is increasing in the MAP industry, most of the packs are still made with four basic polymers.Sometime plastic film does not serve all the properties which required to maintain better quality of food and food products, therefore to achieve the best properties of packaging films are combined with one another or with other materials such as paper or aluminum through coating, lamination, coextrusion and metallization processes [18]. Nowadays the researcher developed some new film variety which has specific functional properties like antioxidant active films, nano-active films, biodegradable films, and micro-perforated films which have been attracted great attention in MA packaging industry.

Micro perforated films

Permeability of packaging material is an important factor to keep food fresh and increase shelf life after packaging [19]. Correct permeability of packaging material achieve desirable equilibrium modified atmosphere and balance the product's respiration rate. Micro perforated films set adequate o2 and co2 level to extend product shelf-life. The gas

exchanges through micro holes within the film and controlled by the gas barrier base which includes the number and dimensions of the perforations. The permeability of micro-perforated film can be adjustable by changing in size, number, density, and the dimension of micro-holes. The gas permeability in micro perforated polymeric films is temperature dependent [20].
The size of the perforations normally used in MAP is between 50 and 200 m in diameter [21, 22]. With micro-perforated film, several studies have been done and show the positive result with extended shelf life than non-perforated film. Themicro perforated film can be developed by a simple technique that is punching of the desired hole in packaging materials.

Biodegradable films

Plastic films are easily available and low in cost and they have good mechanical performance such as tensile and tear strength, good barrier to oxygen, carbon dioxide, anhydride and aroma compound, heat seal ability, and so on. These properties of plastic films increase the use of plastic film as packaging material(23). But in these days use of plastic film has been restricted due to totally non-recyclable and/or non-biodegradable and these properties causing serious environmental problems. The film's biodegradability properties reduce waste products that are good for the environment. Biodegradable materials are degraded by microorganisms into carbon dioxide, water, and inorganic products under aerobic conditions or under anaerobic conditions, it decomposes into methane, carbon dioxide, and inorganic products [24]. Biodegradable polymers are classified into four class. This classification based on their process of synthesis: polymers coming from agro-resources, from microorganisms, those chemically synthesized, and those obtained from biotechnology processes. Starch and cellulose-based polymers are most commonly used in food packaging industry. Cellulose-based polymer cellophane is most common, which is made up of cellulose. Starch-based polymers are amylose, hydroxylpropylated starch, and dextrin. Other starch-based polymers are polylactides (PLA), polyhydroxyalkanoate (PHA), polyhydroxybuterate (PHB), and a copolymer PHB and valeric acids (PHB/V) (25). In biodegradable food packaging, the edible coating is also very popular. Edible coating or films are also made with starch cellulose, chitosan, pectin, wax etc. Edible coating also help to maintain equilibrium atmosphere condition in MA packaging because it is good barrier for moisture and gas.

Nano active films

Nanotechnology is the science of very small materials that has a big impact in food industry including packaging. A variety of nanomaterials such as silver nanoparticle, titanium nitride nanoparticle, and nano-titanium dioxide, nano-zinc oxide, and nanoclay are introduced as functional additives to food packaging [26]. Nanotechnology enabled food packaging can be divided into three main categories [27] i.e. Improved packaging, active packaging, Intelligent/smart packaging. Nanoparticles are mixed with polymer chain to improve the gas barrier properties, as well as, temperature, humidity resistance of packaging. The use of nanocomposite in contact with food is approved by United States Food and Drug Adminstration. The use of nanomaterials is helpful to interact directly with food or environment to allow better protection of the product. Several nano-materials like nano-copper oxide, nano-silver, nano-titanium dioxide, nano-magnesium oxide and carbon nanotubes can provide antimicrobial properties. Presently, the use of silver nanoparticles as antibacterial agents in food packaging is increasing. Intelligent/smart packaging is designed for sensing biochemical or microbial changes in the food. It can detect specific pathogen developing in the food or specific gases from food spoiling. Some smart packaging has been developed to use as tracing device for food safety. Packaging with nano-sensors is useful to trace the external or internal conditions of food products, pellets and containers throughout the food supply chain. Film packed with silicate nanoparticles can reduce the flow of oxygen into the package and leaking of moisture out of package can keep the food fresh.

Antioxidant active film

Antioxidant are compound that inhibit oxidation. Oxidation is a chemical reaction that can produce free radicals, thereby leading to chain reactions that may damage the cells of organisms. Oxidation is one of the most important degradation reactions in foodstuffs, which seriously limits their preservation and has negative influences on nutritional properties such as destruction of vitamins, fatty acids, and organoleptic qualities such as colour changes, off-flavors, off-odors etc. [28]. Oxidation not only influences the sensory quality but reduces the shelf-life of fresh foods, consequently decreases the product sales. In order to retard or minimize oxidative deterioration of foods, antioxidants may be added. Although synthetic antioxidants have long been used in a variety of foods, their uses have come into dispute due to their suspected carcinogenic potential and consumer's preference of natural additives [29]. In addition to natural antioxidants being added directly to foods, active packages with antioxidant properties have received great attention. Antioxidant active films are one of the most promising alternatives to traditional packaging, in which antioxidants are incorporated into or coated onto food packaging materials to reduce oxidation of the food [30]. Compared with direct addition, the active packages technology provides several advantages, such as lower amounts of active substances required, allow slow migration of antioxidants from film to the food matrix, and eliminate additional steps within a standard process intended to introduce the antioxidant at the industrial processing level including mixing, immersion, or spraying [31].

CONCLUSION

Oxygen catalyze the oxidative degradation of foods, particularly of flavor, aroma, and color components. Microbial growth in packaged foods, especially under aerobic atmospheres, causes spoilage of the product. Modified atmosphere packaging is effective in lowering the residual oxygen level in food products. nitrogen usually combined with CO2, has been used for many years as the MAP gas of choice in controlling oxidation of food and extending shelf life of foods. Nowadays in MAP many other gases and oxides of gases are used to obtain better quality product with increased shelf life. In MA packaging, packaging materials also play very important role to maintain good atmosphere within the package. In the packaging field many research has been done to developed new package material with good properties to maintain equilibrium atmospheric condition within the package like transmission of gases, moisture barrier, and flexible etc. But, there are some challenges such as cost associated in designing highly functional packages, requirement of accurate control of storage temperature and requirement of product specific gas compositions.

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