International Journal of Horticulture, Agriculture and Food Science (IJHAF)
ISSN: 2456-8635
[Vol-8, Issue-2, Apr-Jun, 2024]
Issue DOI: https://dx.doi.org/10.22161/ijhaf.8.2
Peer-Reviewed Journal

A Review on Recent Advances of Packaging in Food Industry

Mayur Karate[1], Pramod Bakane[2], Vaishali Sangekar[3], and Udaykumar Khobragade[4]

[1,3]Ph.D. Scholar, Dept. of Process and Food Engineering,
[1](corresponding author) Contact no.: 8830561289, Email Id: mayurkarate@gmail.com
[3]Email Id: vdsangekar2008@gmail.com,
[2]Head, Dept. of Agricultural Process Engineering, Email Id: pramodbakane@gmail.com .
[4]Senior Research Assistant, ICAR-AICRP on PHET, Email Id: udaykhobragade07@gmail.com.
Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra, India – 444104.

Received: 02 Apr 2024; Received in revised form: 07 May 2024; Accepted: 19 May 2024; Available online: 28 May 2024
©2024 The Author(s). Published by AI Publications. This is an open access article under the CC BY license (https://creativecommons.org/licenses/by/4.0/)

***Abstract*— *Effective food packaging provides 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, odours, bacteria, dust, and mechanical damage by maintaining the food quality. The package may also include barriers to keep the product's moisture content or gas composition consistent. Furthermore, convenience is vital role in packaging, and the desire for quick opening, dispensing, and resealing packages that maintain product quality until fully consumed is increasing. To facilitate trading, encourage sales, and inform on content and nutritional attributes, the packaging must be communicative. For storage of food there is huge scope for modified atmosphere packaging, intelligent packaging, active packaging, and controlled atmosphere packaging. Active packaging has a variety of uses, including carbon dioxide absorbers and emitters, oxygen scavengers, antimicrobials, and moisture control agents. Smart packaging is another term for intelligent packaging. Edible packaging, self-cooling and self-heating packaging, micro packaging, and water-soluble packaging are some of the advancements in package material.*

Keywords*— *active packaging, intelligent packaging, oxygen scavengers, CAP, MAP.

I. INTRODUCTION

Packaging is the protection of material containing within it. From the source of production food preparation for storage, sale or travel this art and science or technology used. Packaging has traditionally played an important role in the processing and preservation of food quality. Variations in the production, distribution, storage, and sale of food goods. Food packaging has huge scope and demand for its performance, improved safety, quality, and shelf life for packaged goods continues to grow. Consumers want to be aware that the packaging is performing its job of preserving food quality, freshness, and safety. As a result, advancements in food packaging are both expected and anticipated. Consumer need for packaging is more advanced and imaginative than what is now available has resulted in the development of innovative packaging (Jana, 2024). Food and beverage packaging accounts for 55 to 65 percent of the $130 billion packaging market in the United States (Brody, 2008).

1.1 History of packaging and development

Until the nineteenth century, packaging was just the covering of any goods. The most common uses for newspaper and cloth sacks for wrapping meat and keep flour or sugar. Many products were marketed in bulk because of the paperboard box. By the invention of canning of Nicholas Appert, the era of modern food packaging started in the nineteenth century. In the early 1800s canning of food for preserving long period of time was invented when Napoleon needed better quality rations for his army. Cellophane and polythene revolutionized packaging materials during World War II. As a protective covering for food, cellophane, a clear, flimsy substance, was utilized. As the plastic invented it is used to replace steel, glass, and paper containers in packaging from the 1950s. Plastic containers have more benefits such as: easier to create, lighter in weight, they are less expensive, more resistant to breaking, and shipping is less expensive.

1.2 Important function of food packaging

The significant functions of food packaging are protection, containment, barrier, convenience, marketing, and communication. Protection and preservation from external contamination are the main functions of packaging (Robertson, 2006). This role entails preventing degradation, increasing shelf life, and ensuring food quality and safety of packaged food. Packaging guards the food from environmental effects like light, heat, pressure, oxygen, the presence or absence of moisture, enzymes, microbes, insects, false scents, dirt and dust particles, gaseous emissions etc. Traceability and tamper indication are two secondary roles that are becoming increasingly important (Marsh, 2007).

II. ADVANCED TYPES OF PACKAGING IN FOOD INDUSTRY

2.1 Active packaging

In active packaging supplemental constituents have purposefully added on packaging or in the packaging of the package headspace to improve performance of package system. It is typically employed to protect against oxygen and moisture. It facilitates the package to interrelate with both the food and the surrounding therefore, it play an important role in food preservation. Advances in active packaging include controlled respiration rate, microbial growth, delayed oxidation, and moisture migration (Jana, 2024). Using active packaging technology permselectivity can manipulate which permit the selective gases through packaging material. Permselectivity can be manipulated through micro perforation, lamination, coating, polymer blending, or co extrusion to change the atmospheric concentration of gaseous compounds inside a package in relation with the oxidation or respiration kinetics of foods. Some nanocomposite materials can also act as active packaging by preventing carbon dioxide, oxygen, and moisture from entering the food (Kour, 2013).

Since the last decade, active packaging technologies have received a lot of attention. In 2004, the global market for active packaging films was at $50 million and continuously growing. For food preservation and quality improvement active packaging techniques are divided into three categories: absorbers or scavengers, releasing systems, and other systems. Unwanted molecules such as oxygen, carbon dioxide, ethylene, excessive water and moisture, and other substances are removed through the absorption system. Releasing systems add and release substances like carbon dioxide, antioxidants, and preservatives to packed food and the packaging headspace. Other systems can have additional qualities like self-heating, cooling, and preservation. Active packaging system absorbers and releasers can be sachets, labels, or films, depending on the physical form of food. Sachets can be inserted in the head space of package. Labels can connect to the lid of package. Direct contact of system with food should be avoided because it can affect the function of system and causes migration issues (Jana, 2024).

Nowadays more and more research being done on the use of active packaging in postharvest technology. For example, Aday *et. al.* (2011) has observed alternative packaging methods for strawberries in order to preserve quality and extend shelf life. The study was conducted active packaging using Chlorine dioxide (ClO_2) and ethylene moisture sachets. Four groups of samples were tested for quality properties at 4°C for three weeks. Groups are control, active packaging without ClO_2 treatment, active packaging with low-dose (5 ppm) ClO_2 treatment, and active packaging with high-dose (10 ppm) ClO_2 treatment. Properties like gas concentration, pH, titratable acidity, weight loss, texture profile, soluble solids content, and colour were measured. The most efficient treatment for retaining titratable acidity and sustaining (L) brightness values was active packaging with low dosage (5 ppm) ClO_2 treatment. Total soluble solids in the control group decreased the most, from 7.60 to 6.57. At the conclusion of storage, active packaging without ClO_2 treatment had the lowest weight loss (0.33 percent), whereas the control group had the largest (1.86 percent). These findings suggest that active packaging useful for storage of postharvest commodity.

2.2 Applications of active packaging

2.2.1 Oxygen scavengers

Excess oxygen in packages may cause microbial growth, off odour development, off flavour and, nutritional losses and colour change in food. As a result, food's shelf life is significantly reduced. Therefore, to limit the rate of deteriorative and spoilage reactions in the food the control the level of oxygen in packages is important. An alternative to vacuum and gas flushing, oxygen absorbing systems increase product quality and shelf life. They are also economically viable in terms of lowering costs and raising profits (Kour et al., 2013).

Oxygen absorbing system is compose of chemical oxidation of iron powder or the scavenging of oxygen by enzymes. Sachet material is effectively permeable to oxygen and in some cases to water vapour. Mitsubishi Gas Company developed oxygen scavenging system known as Ageless. The selection of type of absorbent is dependent on nature of the food, permeability of packaging material, amount of soluble oxygen present in food, water activity of food and starting oxygen level in package. This iron-based oxygen absorption system can reduce the oxygen in food, including high, intermediate, and low moisture foods, as well as lipid containing foods. It may be effective in cold and frozen storage condition and Microwavable food products (Remya et al., 2020).

Enzymatic oxygen scavenging system enzyme reacts with a substrate to reduce oxygen. These systems more expensive than iron-based system. This system usually very sensitive to pH, water activity, temperature, and solvent and substrate present in the sachets. As a result, the widespread application of this enzyme-based technology is limited (Ozdemir and Floros, 2004).

For liquid foods oxygen scavenging system may not appropriate because direct contact of liquid with sachets causes sachet contents to leak. Additionally, sachets may be accidentally consumed with liquid food by children. For safety and regulatory reasons, the food and drug administration of the United States suggest that the oxygen scavenging sachets sold labelled with "Do not eat" in United States. Sachets can be packed using secondary packaging however this method increase packaging costs. The use of a scavenger in packaging films is an effective way to solve the sachet problem. There are various methods by which scavengers can be incorporated in packaging like dispersed in plastic, placed into a solid, or inserted into the various layers of the package such as the adhesive and lacquer layers. Multilayer oxygen scavengers absorb oxygen more efficiently than single layer scavengers (Ozcan, 2020).

Use of oxygen scavenger has successfully used in meat industry. Chemical ingredients are either enclosed in a tiny bag that is inserted into the package or are dispersed with plastic materials (components of a low molar mass are dispersed in plastic during production or absorber carrier may be laminated with plastic) (Jana, 2024).

Kartal *et al*. (2012) compares effectiveness for storage stability of fresh strawberries of four biaxially-oriented polypropylene and two biaxially-oriented polypropylene micro perforated films of different transmission rates (7 and 9 holes) with and without oxygen scavengers. Texture profile, total soluble solids, pH, electrical conductivity, FT-NIR analyses, surface colour (L* and a*), gas concentration in trays, and sensory acceptance were measured during storage at 4º C. The oxygen scavenger and micro perforations had a significant impact on maintaining an optimal gas composition within the package for extending strawberry storage life and quality. The authors discovered that packages containing oxygen scavengers performed better than controls in terms of biochemical parameter preservation.

2.2.2 Carbon dioxide absorbers and emitters

High concentration of Carbon dioxide is advantageous in retarding microbial growth on meat and poultry surfaces and delaying the rate of respiration of fruits and vegetables. The package may have a high carbon dioxide permeability which can limit the rate of respiration and suppress microbial growth (Matche, 2001). It is beneficial practise to utilise a dual-function system with carbon dioxide emitter and oxygen scavenger to extend the shelf life of perishable products. If the roasted coffee packed in a container and an aluminium bag, dissolved carbon dioxide released during roasting may cause the package to burst. Carbon dioxide released from freshly roasted coffee can absorb Carbon dioxide with help of scavengers (Brian, 2008). Carbon dioxide sachets consist of a porous envelope containing calcium oxide and ingredient like silica gel that absorbs water. Water combines with calcium oxide and form calcium hydroxide, which reacts with carbon dioxide to form calcium carbonate (Jana, 2024).

Aday et al. (2011) evaluated the effect of active modified atmosphere packaging on the freshness of fresh strawberries and used carbon dioxide absorbers. During storage at 4°C for 4 weeks, strawberries were treated with one oxygen and two different carbon dioxide scavengers. Comparing pH, total soluble solids, electrical conductivity, texture profile analysis, gas concentrations, surface colour, sensory analysis, decay incidence, and FT-NIR analysis results, the influence of active packaging was determined. In controls samples (packaging without absorbers) pH levels during storage were significantly higher than in the other treatments. CO_2 accumulation was lowest in the package headspace with CO_2 absorbers, whereas O_2 absorbers maintained consistent O_2 levels (5 kPa) at the time of storage. All treatments had total soluble solid level between 10.34 percent and 7.7 percent except for the control, which had a total soluble solid content of 6.94 percent at the end of storage. CO_2 absorbers are helpful for maintaining biochemical parameters. Throughout storage, CO_2 absorbers had the lowest electrical conductivity, and colour retain in all treated fruit. The control sample firmness values were substantially lower than the treated samples. Sensory evaluation revealed that the controls scored the lowest on all attributes.

2.2.3 Moisture control agent

Excess moisture in packaging can change texture of moisture-sensitive foods, softening of crunchy products like chips, moistening of hygroscopic products like sweets and confectionery and causing caking in powdered items. In contrast, excessive moisture loss from food can lead to product desiccation. Moisture control agents help to reduce microbial development by controlling water activity, preventing condensation from fresh food, slowing down lipid oxidation and absorbing melting water from frozen products and blood or fluids from meat products. For dry foods, desiccants such as natural clays, calcium oxide and silica gels are used, while for high moisture foods, internal humidity controllers are used (for example, fruits, and vegetables, poultry, meat). Various form of desiccant like perforated water-vapour barriers, plastic cartridges, internal porous sachets, etc. Humidity controllers maintain an optimal in-package relative humidity (around 85% for cut fruits and vegetables), reduce moisture loss, and prevent excess moisture from accumulating in headspace and interstices, where microorganisms able to grow. Absorbers remove liquid squeezed or leaking from fresh items (Aday, 2011).

Brian (2008) reported that a Japanese company named Showa Denko Co. Ltd prepare a Pitchit film which is made up of a layer of humectant carbohydrate and propylene glycol sandwiched between two layers of polyvinyl alcohol (PVA) plastic film. It is sold in rolls or single sheets for wrapping fresh poultry, fish, and meats at home. The surface of the food is dehydrated by osmotic pressure after wrapping in this film, resulting in microbial inhibition and a shelf-life extension of 3 – 4 days under chilled storage. Another application of moisture control agent is in distribution of horticultural produce. Tomatoes were distributed in the United States using microporous sachets of organic salts such as sodium chloride as a desiccant.

2.2.4 Antimicrobials

Due to various diverse physiologies of antimicrobials agents have variable effects on different pathogenic microorganisms. Antimicrobial agents can be incorporated directly into food particles or into packaging materials, where they are released over time to maintain product quality and safety, resulting in extending shelf life. Due to environmental concerns over synthetic polymer-based packaging materials, edible film coatings are more popular. Within the biodegradable active packaging idea, edible packaging films with antimicrobial coatings have provided scope of innovation. It is helpful for reducing and inhibiting microorganism growth on the surface of food products. In terms of stability polymer-based film solution coating has proven to be the most stable technique of attaching a bacteriocin to a plastic packaging film (Malhotra, 2015).

Antimicrobial packaging film diffuses bacteriocins to the surface of packaging and prevent microbial growth. The controlled release of bacteriocins from food packaging film is significant than dipping or spraying foods over food surface. Inactivation of the bacteriocins may cause due to mixing of bacteriocins into the dietary components lead to significant dilution of concentration of antimicrobial property (Appendini and Hotchkiss, 2002).

Franke *et al.* (2002) reported that emission of ethanol in the package environment of bakery products have been shown to extend the shelf life of the products. Ethanol helps to reduce the mould and bacteria, yeasts and moulds on the surface of the product by lowering the water activity of the product. Ethicap is a sachet that contains ethanol, silicon dioxide, and a small bit of vanilla or citrus flavour to cover up the ethanol. For extending the shelf life of the prebaked buns the ethanal release the vapour in the headspace of the package from 4 to 17 days. Using ethanol emitters may be disadvantageous because ethanol being adsorbed by the food product from the package headspace, 60mg/kg food migration limit allowing the European legislation to be easily exceeded.

2.3 Intelligent or smart packaging

Intelligent packaging is defined as packaging which provide information about the history and quality of package and food it contains which is made of external or internal indicator. The condition of packaged foods is monitored by intelligent packaging systems, which provide information about their quality during transport and storage. Intelligent packaging is nothing but the communicational packaging which is form of conventional packaging. It has ability to sense, detect, or record external or internal changes based on its ability in the product environment and provide information to the consumer. It may include ripeness indicators, radio frequency identification, time temperature indicators, and biosensors. External and internal indicators are the two types of indication systems that can be used. External indications such as time, temperature indicators and internal indicators such as oxygen indicators for indication of oxygen or package leak, microbial growth indicator, and pathogen indicator are placed outside of the package (Jana, 2024).

Intelligent packaging can carry out several intelligent functions such as recording, communicating, tracing, detecting, applying scientific logic and sensing to help in decision making to extend enhance safety, shelf life, provide information, improve quality and warn problems. The uniqueness of Intelligent Packaging is, it has ability to communicate because throughout the supply chain cycle package and the food move constantly together, the package is best companion of food to communicate the conditions of the food within it. The best advantage of intelligent packaging is that without opening package it aware to the consumer about condition of product during transport and storage (Kour, 2013).

Quality indicators, and/or gas indicators and TTIs, are commonly found in intelligent packaging. The important factor which determines the kinetics of physical and chemical deterioration, as well as microbiological development in food products, is temperature. TTIs are in form of self-adhesive labels that are attached to transport containers or individual packages. These labels show the temperature history during storage and distribution, which is especially effective for warning of temperature mishandling in chilled or frozen foods. They are also utilised as "freshness indicators" which help to evaluate the remaining shelf life of perishable product. Along with distinct temperature dependent changes these labels frequently respond such as with increase colour intensity and dye diffusion along a straight line. Partial history indicators, full history indicators and critical temperature indicators are the three fundamental forms of commercially available TTIs (Svensson, 2004).

Attempts have been made in design intelligent packaging using biosensors called intelligent devices that made of bioreceptor identifies an antigen, microorganism, enzyme, nucleic acid, hormone, along with a transductor which is closely related to the specific character of the measured parameter (Kour, 2013).

Shimoni *et al*. (2001) reported that 'Indication band' is a strip contain di-acetylene monomers which appears colour less as it absorbs light only in UV range. When there is a change in colour it will indicate temperature change.

2.4 Modified atmosphere packaging (MAP)

The technology of modified atmosphere packaging (MAP) is used to extend the shelf life of fresh or minimally processed foods. Food packing in modified atmosphere is well recognized technology. Initially for the production and packaging of cheese and coffee, among other items, only carbon dioxide and nitrogen were utilized as separate gas. Carbon dioxide, oxygen and nitrogen are the most common gases utilised in MAP. European Community permitted for the use of gases like carbon monoxide, helium, argon, and other gases for MAP (Zhou, 2010). Air surrounding the food in the package is altered to a different composition in this preservation technology therefore the initial freshness of the product is maintained. As MAP slow down natural deterioration of product the shelf life of product perishable products such as fruits, vegetables, fish and meat extended. MAP is utilised with a variety of product, and the gas mixture in the container is determined by the storage temperature, packaging materials, and product type. For non-respiring products like cheese, fish, meat, etc. high barrier and low gas permeability films are used. Inside the MA package, the initial flushed gas combination is same. But vegetables and fruits are respiring products therefore that products require interaction between product and packing. If equilibrium modified environment will form in the package by adopting permeability of packaging film for O_2 and CO_2 according to product respiration then shelf life of the product gets extended (Datta, 2015).

Nitrogen, oxygen, and carbon dioxide concentrations in MAP are 78 percent, 21%, and 0.035 percent, respectively, with water vapour and traces of inert gas. A single gas or a mixture of gases is integrated in the packaging. When a mixture is incorporated the proportions of each component fixed. Changing the headspace atmosphere and extend the shelf life of polymeric packaging containers sometimes various additives are added this packaging refer as active packaging. Passively, a modified atmosphere can be formed in this respiring product is enclosed in a polymeric packaging and hermetically sealed. Only the product respiration and the gas permeability of film influence gas composition around product. Beneficial modified environment may passively formed in package if the product respiration characteristics are suitably match to the film permeability values. For example, if a film is good to resist moisture but not for oxygen, still it can be used in combination with an oxygen scavenger to keep oxygen out of the pack. Similarly, ethanol emitters, ethylene absorbers and carbon dioxide absorbers or emitters can be employed to regulate oxygen levels inside the modified atmosphere pack. Oxygen reacts with the foodstuff resulting in the oxidative breakdown of food into its constituent parts therefore minimum oxygen levels are maintain in store food under MA (Jana, 2024).

2.5 Controlled atmosphere packaging

The atmosphere of the food is continuously monitored and controlled in controlled atmosphere packaging. It involves mainly the control of carbon dioxide, oxygen, temperature, relative humidity, etc. Vacuum packing which widely used, it involves removing air from the packaging before sealing it tightly. Many adverse changes occur when oxygen is present in packing including changes in flavour and aroma, autoxidation of fats (rancidity), oxidation of pigments like vitamin E, vitamin C, beta-carotene, and amino acids, and the formation of aerobic microorganisms like moulds. Therefore, removing oxygen from the medium can prevent the growth of moulds, aerobic bacteria and yeasts and which cause food degradation (Kour, 2013).

III. ADVANCED TYPE OF PACKAGING MATERIALS

There ae several advances in food packaging materials have investigated in now days. Some important material of food packaging is discussed below.

3.1 Edible packaging

Food is usually packaged in film of edible material with other edible product it is advantageous in terms of reducing problems like pollution. The best use of edible packaging is that it lowers food waste and financial expenditure. Edible sheets, coatings, pouches, and films are the most common types of edible packaging. Edible films of thickness 254 µm or sheets of thickness >254 µm are preformed structures that are placed on or between food components or sealed into edible pouches separately from the food. Edible coatings are thin layers of edible materials formed directly on surface of food products. Edible packaging includes hard-gel capsules, microcapsules, soft-gel capsules, and tablet coatings which made from edible materials. This evaluation is mostly concerned with edible coatings, pouches, and films (Janjarasskul and Krochta, 2010).

To replace polluting plastic materials and improve safety, shelf life and storage, researchers of University of Nottingham developed 100 percent biodegradable and edible food packaging manufactured from plant carbohydrates and proteins.

LoliWare is a startup that makes edible agar-based cups and a shell that can store foods and beverages made from food particles. Over a century in Japan edible rice paper-wrapped confection prepared by While Bontan Ame (Savenije. 2013).

3.2 Micro Packaging

Micro packaging developed using nanotechnology, it has influence on pharmaceutical packaging because it has ability to improve shelf life and drug stability. New drug delivery techniques and creation of new biological chemicals, improve protection against factor such as mechanical forces, oxygen, light, and moisture. In micro packaging the incorporation of certain nanoparticles into shaped objects and films to protect from light, fire, mechanical and thermal strength, and gas permeability. Micro packaging, which incorporates nano-engineered materials like nano coatings and nanocomposite-based packaging films help to inhibits microbiological development, increases tamper visibility, delays oxidation, and prevents counterfeiting by ensuring drug safety for longer period (Anonymous, 2016).

To improve barrier properties for oxygen, clay nanoparticles incorporated into an ethylene-vinyl alcohol copolymer and a poly (lactic acid) biopolymer. This type of packaging has potential to enhance the shelf life of food products. Also, gas barrier characteristics, mechanical strength, and thermal stability are advantages of polymer-silicate nanocomposites. Nanotechnology has modified permeability behaviour, improved heat, and mechanical resistant properties, produced active antibacterial surfaces and signalling, and sensed microbiological and biochemical changes. An "electric tongue" developed by University of Rutgers in the United States for use in packaging. It is made of nano sensors which are particularly sensitive to gases emitted by spoiled food and give signal by changing colour of sensor strip, indicating whether the food is fresh or not (Kour, 2013).

Yang *et al*. (2010) developed a new packaging film to preserve fresh strawberries at 4°C using a unique packaging material made of combining polyethylene with titanium oxide nano powder and silver nano powder. It was observed that decay rate in nano-packing was slower than in normal packaging. TSS and ascorbic acid concentration decreased considerably after 12 days of storage when compared to normal polyethylene packaging.

3.3 Water soluble packaging

When this type of packaging dissolve in hot water therefore also known as vanishing packaging. It saves cost on transportation by delivering dry powders first and then creating the final product after it arrives at its destination. It is mainly made of PVA (Poly Vinyl Alcohol) which decreases pollutants, simple to use, and is unlike anything else on the market.

A US company named MonoSol manufacture water-soluble product has developed edible delivery systems which are essentially water-soluble food pouches (Savenije. 2013).

3.4 Self-cooling and self-heating packaging

It can maintain the temperature to according to required conditions for this process it usually contain some chemical or mechanical technology. Beverage packaging it is type of active packaging. When the activation button is pressed technology absorbs carbon dioxide from the atmosphere and releases it. In self-heating packaging system calcium or magnesium oxide and water are used to create an exothermic reaction. It is mostly used for plastic coffee cans, military rations, and other products. Evaporation of an external compound that eliminates heat from the product is used in self-cooling packaging mostly water which evaporated and adsorbed on surfaces (Dawange, 2010).

An international company Joseph developed Chill Can which is a device that adsorbs carbon dioxide from the atmosphere and releases it when the activation button is pressed, allowing the liquid within the can to cool to 30 degrees Fahrenheit in minutes.

Similarly, A company Heat Genie and Crown Holdings have created Heat Genie, a self-heating component which can heat a product to 145 degrees Fahrenheit in two minutes and is designed to be implanted at the bottom of container (Savenije. 2013).

IV. CONCLUSIONS

Packaging is important to protect the food product and it is important part of the supply chain. It provides various important function like protecting food from outer environment and easy handling of product. Recent advancements in packaging technology have resulted in significant development, improvement, and benefits for both consumers and industry. There are several advances packaging in packaging sector which provide variety of functions like controlling growth of microorganisms, maintain the temperature and gas concentration, relative humidity in package, communicating with the consumer, detection of product freshness, etc. Intelligent packaging and active packaging are new advances in packaging which are helping to control microbial growth, respiration rates, and volatile flavours and aromas.

Nanotechnology has great potential to have significant impact on the packaging industry. Pathogen detection, active packaging, and barrier formation are all examples of nanoscale advances. There is great demand to develop scavengers which can response quickly and made of degradable, toxic free and edible packaging materials which are safe humans and the environment. Development of indicator and others has lot of interest in the field of food packaging research. In future there may be such indicator will develop and used in packaging sector.

REFERENCES

[1] Aday S, Caner C.2011. The Applications of ‘active packaging and chlorine dioxide for extended shelf life of fresh strawberries. Packaging Technology and Science, 24.3: 123–136.

[2] Anonymous.2016. Micro packaging – an evolving packaging technology, Market research report, https://www.marketsandmarkets.com/Market-Reports/micro-packaging.

[3] Appendini P, Hotchkiss JH.2002. Review of antimicrobial food packaging, Innovative-Food-Science-and-Emerging-Technologies, 3(2): 113-126.

[4] Brian PF.2008. Active Packaging of Food, Smart Packaging Technologies for Fast Moving Consumer Goods.

[5] Brody A, Bugusu B, Han J, Sand C, Mchugh T.2008. Innovative Food Packaging Solutions, journal of food science, 73 (8): 107- 116.

[6] Datta S.2015. Recent Advancement of Packaging Technology for Fish Products, Principal Scientist ICAR-CIFE Kolkata Centre.

[7] Dawange S, Dash S, Patil S.2010. Smart packaging and food industry, Indian Food Industry 29 (5), Department of Agricultural Processing and Food Engineering College of Agricultural Engineering & Technology, Bhubaneswar- 751 003, Orissa.

[8] Franke I, Wijma E, Bouma K.2002. Shelf life extension of pre-baked buns by an active packaging ethanol emitter, Food-Additives-and-Contaminants, 19(3): 314-322.

[9] Jana A. 2024. Food packaging technology, Active and intelligent packaging, https://ebooks.inflibnet.ac.in/ftp08/chapter/active-and-intelligent-packaging.

[10] Janjarasskul T, Krochta J.2010. Edible Packaging Materials, Annual Review of Food Science and Technology, Department of Food Science and Technology, University of California, Davis, California.

[11] Kartal S, Aday M, Caner C.2012. Use of microperforated films and oxygen scavengers to maintain storage stability of fresh strawberries, Postharvest Biology and Technology, 71: 32–40.

[12] Kour H, Ahmad N, Wani T, Malik A, Kaul R, Chauhan H, Gupta P, Bhat A.2013. An international journal for reviews in postharvest biology and technology, Division of Post-Harvest Technology, Sher-e-Kashmir University of Agricultural Science and Technology, Jammu, India.

[13] Malhotra B, Keshwani A, Kharkwal H.2015. Antimicrobial food packaging: potential and pitfalls, Amity Institute of Biotechnology and Amity Centre for Carbohydrate Research, Amit, Amity University, Noida, India.

[14] Marsh K, Bugusu B.2007. Food packaging: roles, materials, and environmental issues, Journal of Food Science, 72(3):39–55.

[15] Matche RS.2001. New trends in fresh produce packaging, Indian-Food-Industry, 20 (6): 58-64.

[16] Ozcan A. 2020. New approaches in smart packaging technologies, Invited lecture, 21 – 37. https://doi.org/10.24867/GRID-2020-p1.

[17] Ozdemir M, Floros JD.2004. Active food packaging technologies, Critical reviews in food science and nutrition, 44(3), 185-193.

[18] Remya S, Mohan CO, Ravishankar CN.2020. Oxygen Scavenger Packaging for Seafood Preservation, Fishery Technology, 57: 147 – 155.

[19] Robertson GL.2006. Food Packaging – Principles and Practice. Second edition, CRC Press, Boca Raton, FL, USA.

[20] Savenije D. 2013. 6 futuristic food packaging technologies that could change everything, https://Savenije. 2013/news/6-futuristic-food-packaging-technologies-that-could-change-everything.
[21] Shimoni E, Anderson EM, Labuza TP.2001. Reliability of time temperature indicators under temperature abuse, Journal of Food Science, 66(9): 1337–1340.
[22] Svensson A.2004. Active food packaging-Materials and interactions, a report of Department of Chemical Engineering, Karlstad University, Karlstad, Sweden.
[23] Yang FM, Li HM, Li F, Xin ZH, Zhao LY, Zheing YH, Hu QH.2010. Effect of nano-packing on preservation quality of fresh strawberry (Fragaria ananassa Duch. Cv Fengxiang) during storage at 4°C, Journal of Food Science, 75: 236–240.
[24] Zhou GH, Xu XL, Liu Y.2010. Preservation technologies for fresh meat - A review. Meat Science, 86: 119 – 128.