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A Review on Biodegradable Packaging Materials in Extending the Shelf Life and Quality of Fresh Fruits and Vegetables

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ABSTRACT

Different packaging techniques were employed to reduce the post-harvest losses nearly about 30-40 % of total production of fruits and vegetables, to improve the quality & safety aspects of the produce, to combat the market price which in turn increases demand in the market to earn profits. In order to maintain the quality and safety aspects of fruits and vegetables many traditional technologies were adapted but that doesn't suffice the requirement in maintaining the extended shelf life. In the recent past, several emerging technologies which are eco-friendly has a huge potential was used to maintain the safety and quality parameters of fruits and vegetables but still has certain limitations for each of its techniques.

INTRODUCTION

Globally in today's scenario the most common problem and threat to the environment is due to plastic packaging waste (Singh et al., 2018). Most of the plastic waste around 75-80% is ended up in landfills and only 10-15% of which is recycled successfully (Sharuddin et al., 2016). In recent years there is a huge demand in development of sustainable packaging in order to improve the ecological footprint and environmental impact (Rodriguez-Perez et al., 2018).Biodegradable plastics found its way easier for repurpose or recycle that shows much impact in reducing the waste streams and environmental friendly (Attaran et al., 2017).Polymer based packaging materials cause great threat to environment evolving huge amount of carbon dioxide during oxidation by microorganisms (Li et al., 2017). Degradation of this packaging material by microorganisms leads to fragmentation which in turn forms the shortening of polymer chains cause breakage and stretching (Leja and Lewandowicz, 2010).The main aim of this review is to summarize different types of packaging systems as well as the biodegradable materials for fresh cut fruits and vegetables to increase the shelf life and to maintain the barrier properties similar to the polymer based packaging materials.

Modified atmospheric packaging

In order to extend the shelf life of fruits and vegetables using controlled atmosphere by depleting the oxygen (O2) levels and to increase carbon dioxide (CO2) in combination with refrigeration (Dilley, 2006) Table 2.

Another best practice, to increase the shelf life is by Controlled Atmosphere (CA) storage in this optimum concentration of different levels of gas composition maintained in storage room and finds its exclusive benefits over refrigeration. CA storage for fresh cut fruits & vegetables is useful in preventing the diseases and to reduce the storage disorders (Prange et al., 2005).

In order to retain the firmness and to maintain the quality of fruits hydro or forced air cooling is used to reduce the O2levels by purging the Nitrogen which in turn considered as rapid controlled atmosphere storage for depleting the ethylene synthesis (Vigneault and Artes-Hernandez, 2007).

Various limitations to use newer technologies of CA due to its low financial returns and adaption in storage of fresh fruits & vegetables. The use of biodegradable packaging with combination of either CA/RCA need to be evaluated for further examination of produce for its safety and quality aspects.

Active packaging and intelligent packaging

Active food packaging is an innovative approach keeping in view the consumer demands like more convenience, shelf life improvement which includes the study of various processes like physical, chemical and microbiological aspects of appropriate packaging systems. During transportation and in order avoid cross contamination for fresh fruits & vegetables various such challenges needs to be taken into account to increase the shelf life, quality, food safety and to improve the sensory properties by modifying the conditions in the packaging systems (Vermeiren et al., 1999).

Intelligent packaging helps to monitor the packaging conditions such as tracing the carbon dioxide and oxygen levels, detecting with respect to time vs temperature history, recording/identifying the food borne pathogens and sensing mechanical, chemical and enzymatic reactions etc (Wilson, 2007).

Modified atmospheric packaging technique can be used to alter the gases mixture composition thus decreasing the oxygen levels and maintain the carbon dioxide levels depending upon the type of fruits and vegetables but this technology has its own limitations with respect to lipid oxidation (chemical process), microbial growth spoilage (microbiological studies), fruits and vegetables respiration (physiological process). All this various process can best be controlled by different ways using active packaging systems and thus increases the shelf life of packaged produce (Yam, 2010).

Edible packaging films

Edible coatings in the packaging systems are bio-based materials means it need not be biodegradable material. This film acts as a primary packing material for fruits and vegetables by acting as a barrier from oxygen, moisture and carbon dioxide thus protecting from spoilage by lowering the gaseous exchange, reducing physiological disorders, respiration rate is reduced, texture improvement and volatile compounds were thus retained (Rojas-grau et al., 2009).

By incorporating micronutrients like vitamins, essential minerals and essential fatty acid components into the edible films will help to improve the nutritional properties of fruits and vegetables which are less in micronutrients.

Nanocomposites for fruits and vegetable packaging

Currently, the use of nanoparticles in commercial packaging systems has less application for fruits and vegetable packaging. Nanoparticles in the range of 10-100 nm are widely used for exhibiting the reactivity of the material by any of the two approaches either self-assembly or bottom down and top down in these processes surface to volume ratio is increased and thus helps in to increase the surface particles number (Ward and Dutta, 2005).

Most of the active packaging and conventional type packaging are replaced by nanocomposite films to increase the quality, safety and shelf life aspects of the packaged food products. In order to have a uniform distribution of antimicrobial activity, the use of nanoclay with antimicrobial agent in the polymeric blend helps to improve the mechanical and antimicrobial properties of packaging systems. Thus various nanoparticles were used such as aluminum hydroxide, carbon tubes, silicates, titanium oxides etc. (Pandey et al., 2005).

Table 1: Table 1: List of vendors that produce modified atmospheric packaging (Brody et al., 2010; Parry, 2012; Haugard and Martensen, 2003; Guillin, 2001)

Company	Country	Web Page
Bemis	United States	www.bemis.com
Berry Plastics	United States	www.berryglobal.com
Dansensor	Denmark	https://Dansensor.com/
Linde	Germany	www.linde.com
Sealed Air	United States	https://sealedair.com/
Amcor	Australia	www.amcor.com
G. Mondini	Itlay	www.gmondini.com
LINPAC	England	www.linpacpackaging.com
ORICS	United States	www.orics.com
Point Five Packaging	Chicago	www.p5pkg.com
StePac	Brazil	www.stepac.com
Total Packaging Solutions	India	www.totalpackagingsolutions.in
Harpak-ULMA Packaging	United States	www.harpak-ulma.com
Winpak	Canada	www.winpak.com

Table 2: Application of different concentrations of oxygen and carbon dioxide gases for various commodities of fruits and vegetables. (Han, 2005;Truter et al., 1994).

Oxygen (O_2) %[a]	Carbon dioxide (CO_2) %[a]	Commodity
Fruits		
2-3	2-3	Apricot
2-3	5-10	Avocado
2-5	3-5	Banana
5-10	15-20	Blackberry
5-10	15-20	Blueberry
3-10	10-15	cherry
1-2	0-5	Cranberry
5-10	15-20	Fig
2-5	1-3	Grape
3-10	5-10	Grape Fruit
1-2	3-5	Kiwi
3-5	5-10	Mango
1-2	3-5	Nectarine
5-10	0-5	Orange
3-5	5-10	Papaya
1-2	3-5	Peach
3-5	5-8	Persimmon
3-5	5-10	Pineapple
1-2	0-5	Plum
5-10	15-20	Raspberry
5-10	15-20	Strawberry
Vegetables		
21	10-14	Asparagus
2-3	2-3	Artichokes
2-3	3-7	Beans
1-2	5-10	Broccoli
1-3	5-10	Brussels Sprouts
2-3	4-6	Cabbage

Table 3: : List of vendors that produce active and intelligent packaging systems (Day, 2008; Lopez-Rubio et al., 2008; Smolander, 2008; Realini and Marcos, 2014; Pereira et al., 2012).

Company	Country	Web Page
BASF SE	Germany	www.basf.com
Amcor	Australia	www.amcor.com
Honeywell International Inc.	United States	www.honeywell.com
Landec Corporation	United States	www.landec.com
Bemis Company	United States	www.bemis.com
Crown Holdings Inc.	United States	www.crowncork.com

Antimicrobial compounds are used in nanocomposite films directly in compounds form or as coating itself to control the growth of microbial spoilage (Appendini and Hotchkiss, 2002; Persico et al., 2009). The use of silver nanoparticles as antimicrobial particles for control release of active properties into the packaging material for longer period. Many researchers stated the use of titanium oxide nanoparticles in the packaging show greater antimicrobial properties than the silver nanoparticles (Duncan, 2011).

Concern regarding the use of nanoparticles stating that these are more toxic than their counterparts of macro sized particles which doesn't show any biological activity as like that of micro sized particles (Taylor, 2008).

Due to consumer awareness to novel packaging techniques like active packaging, use of nanoparticles has made a new era and widened up the research area especially in developing countries like India to invest more on the quality and safety aspects. More studies need to be conducted on the interaction of this emitters and absorbers on the packaging conditions. Also studies should focus on the use of antimicrobialproperties but keeping in mind the cost of the package, present packaging machineries in food industries also need to utilized efficiently are the challenges faced by this new packaging techniques implementation. The use of nanoparticles in active packaging systems need to be concentrated more on the permeability, releasing into the packaged foods and susceptibility of the packaged films.

Use of modified atmospheric packaging individually or in combinations with other techniques has increased the demand in recent trends because of its longer storage period due to various aspects like transportation, wholesaler and retailer etc. Various combinations of gases like nitrogen, carbon dioxide and oxygen were used depending upon the type of produce along with use of scavengers within the package. Intelligent packaging technique with MAP for monitoring the release of ethanol gas and to detect the low oxygen levels in order to improve the odor/aroma of the packaged food (Zhang, Y., et.al 2007).

The use of individual modified atmosphere for fruits and vegetables have not been investigated in detailed. There is no clear understanding that use of MAP will enhance the physiological disorders and mechanism for initiation of these disorders are not depicted. Further investigation need to be evaluated on the use of MAP with novel technologies like intelligent and active packaging techniques and it is important to study the microbial pathogens and food borne parasites on this produce. Huge scope in combination of edible packing films with MAP for commercialization purpose.

CONCLUSION

Biodegradable packaging materials have been the topic of many studies of last two decades. The current applicability of biodegradable packaging materials for both short shelf- life as well as long shelf- life products which don't require that much excellent oxygen and or water barrier properties necessitate the commercial exploitation of these bio-based packaging materials. Biodegradable films should possess some barrier properties like WVTR, OTR and moisture in order to compete commercially with plastic packaging. Several studies were conducted to evaluate the biopolymer based packaging materials to increase the shelf life and ecofriendly to the environment for fresh cut fruits and vegetables. The current trend for biodegradable packaging films implemented and produced by industries on commercial level due to several cumulative efforts and further research is required to widen up its importance in its counterparts.

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