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Comparative Analysis of Biodegradable and Edible Food Packaging Materials Derived from Natural Ingredients

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Abstract

The conventional method of packaging utilizes petrochemical polymers that result in pollution. Edible polymers, also known as green polymers, are an integral part of food items that can be consumed and biodegraded, preserving and wrapping the food item for storage and transportation. The edible food packaging materials has attracted consumers with their potential to overcome the challenges faced by polyethylene packs. However, Shelf life, antibacterial, antimicrobial, tensile strength and elongation at break of the edible films need to be assessed to commercialize. Natural ingredients with nourishing nutrients will also satisfy the non-poison packages for the food items. Natural raw materials used in the past studies to cast edible films are reviewed to find the most suitable packaging material. This paper aims to analyze various aspects of three different edible and biodegradable films and open up areas for further study.

Keywords: Edible and biodegradable films, Shelf life, Mechanical property, Plasticizer.

Introduction

Food packaging materials have gained importance in the last decades due to the objective of the suppliers to provide clean and healthy food materials to the consumers without any contamination and spoilage. Worldwide, petrochemical polymers are used to make facile and ethereal packaging [1]. A study in 2015 reveals that around 49 million tons of plastic wastes were collected every year, out of which 39.9% were food packaging materials [2]. US EPA agency recorded in 2017, total plastic products generation were 35.4 million tons that are 13.2 percent of Municipal Solid Waste generated. This shows a rise of four million tons from 2010 to 2017, and it came from food packaging categories and drinking packages. [3] Without consciousness, plastic materials are implanted into the environment, causing soil pollution, piles of waste on the roadsides, and choking water sources that endanger our society. Waste management has become an urging area for researchers to innovate new technologies to control pollution and maintain the sustainability of nature. Due to the government's enforcement to reduce pollution and achieve zero waste, many technologies are induced. Some of the trending areas were waste to energy conversion, biodegradable materials, cleaner production etc. Researchers suggested that to reduce

the waste at the source, and petrochemical polymers can be replaced with edible materials for food packaging as it was observed as the major pollutant that is not retrieved for recycling [4].

Literature Review

Mohamed S. Abdel Aziz et al. elucidates research on improving the shelf life of the edible packaging material. In the process, alginate was incorporated with different ratios of castor oil and compared for its antibacterial property. Alginate is a phrase used to represent alginic acid and its all derivates. Alginate didn't possess any influence against the bacterial activity, but the incorporation of Castor oil ameliorates the antibacterial feature of the packing material. The composition has a repressive effect on Gram-positive bacteria and no repressive effect on Gram-negative bacteria. The study revealed that Castor oil increases the edible packaging material's thermal stability, mechanical property, and antibacterial property [5].

Chandra Mohan et al. has developed a nature-oriented food and meat packaging material using natural Plasticizer, tamarind seed starch rich in polyphenols with gelatin induced with species like Syzygium aromaticum and Cinnamomum cassia that are rich in antioxidants. Characterization of the edible film had been done to estimate the mechanical properties, antibacterial and antioxidant activities. Tamarind seed starch became a supplement matrix for preparing an edible packaging material, insulating it from bacteria, and enriching it with antioxidants, and adding selective spices [6].

Ivan Shatalov et al. has investigated and progressed a protein-based edible packaging material with enhancing mechanical property, preservative property and antimicrobial property. Raw materials used are porcine gelatine as a base, microbial transglutaminase as a preservative and glycerol as Plasticizer. Mechanical properties and Bacteriostatic activities were studied to analyze the application of edible packaging. Protein films had high barriers properties, but they were fragile with low stability to water vapour. The study had designed an edible protein film with cherished preservative and antimicrobial enzymes [7].

Anjum Nawab et al. has studied a sealable heat pouch made of mango kernel starch for storing red chilli powder. The fabricated sealing pouch comprises naturally derived mango kernel starch and a 1:1 ratio of glycerol and sorbitol. The test samples were noted for similarity with the control sample of regular petroleum-based polyethylene wrapper. It was identified that loss of pungency of the chilli powder sustained with the lowest value of 15.7 % for the Mango kernel seed pouch and with the highest value of 25.9% for polyethylene. It also shows that colour change in chilli powder was less in the Mango kernel seed pouch than Polyethylene [8].

Butsadee Iamareerat et al. applied green technology of biodegradable packaging material to replace the conventional polyethylene material. The biodegradable packaging material consists of cassava starch, sodium bentonite, glycerol and cinnamon oil. Cassava, an economic starch-based source, aid film-forming property and common plasticizers like glycerol provides a transparent and brittle film for storage. The addition of cinnamon oil and nano clay particles enhances the

starch film's antimicrobial property to store pork meatballs. The study analyses the shelf life of food products without preservation in refrigeration conditions [9].

Jorge Padrao et al. reports edible packaging material made of bacterial cellulose obtained from different sources by static culture and commercial source. The film is assessed as edible, antimicrobial and tensile packaging for highly perishable food items such as meat products. The product was characterized by finding water permeability, mechanical property and antibacterial activity against microorganisms. To track the changes in bacterial cellulose, Vitro gastrointestinal tract model was used and showed maximum tensile strength [10].

Comparison of properties of the natural edible film

Edible packaging materials were made up of green polymers as plasticizers to provide strength and flexibility to the film. Apart from conventional polyethylene, edible packaging materials are enriched with natural ingredients to increase the film's shelf life and make it nutritive. Table 1 Indicates the comparison of properties used and analyzed by the authors in their study.

Anjum Nawab et al. modelled an edible film using Mango kernel seed starch as a plasticizer and sorbitol and glycerol. Using 70% plasticizer, maximum sealing strength was obtained. The study has not determined the mechanical property and antibacterial activity of the developed film. Tamarind seed, considered waste, contains many nutrients and is utilized to create an edible packaging enriched with ball-milled clove and cinnamon spices. It utilizes less glycerol than edible packaging from mango kernel but more than edible packaging from cassava starch. Tamarind seed starch with spices are designed by Chandra Mohan et al., uses Xanthan gum to gelatinize the film.

Butsadee Iamareerat et al. determines that clay and starch enhance the physical and mechanical properties of the film. Water vapour permeability proves that the hydrophilic nature of cassava starch and essential oils cross links the polymers to improve the film's tensile strength. The Sodium bentonite clay aided in the film is a natural component. The Mango kernel seed starch film provides a shelf life period of 120 to 180 days when incorporated with capsaicin content in red chilli powder. Heat sealing property that makes the pouch for commercialization is observed in mango kernel seed starch film. Tensile strength of tamarind seed starch with spices has been measured high as 48.24 Mpa. At the film's break, elongation with reinforced Cassava starch and essential oil detected a maximum of 72.79%.

Properties	Edible packaging material made of Mango kernel seed starch	Edible packaging material made of Tamarind seed starch with spices	Edible packaging material made of Reinforced Cassava starch with essential oil and sodium bentonite clay
Plasticizer used	Glycerol	Glycerol	Glycerol
Starch utilized	Mango Kernel Seed starch	Tamarind Seed starch	Cassava starch
Preservative	Mango kernel Seed starch	Ball milled spices (*Syzygium aromaticum* and *Cinnamomum cassia)*	Cinnamomum cassia oil
Shelf life	120- 180 days	Not determined	9 -21 days
Best of the combination made	Glycerol (70%)- Plasticized film	Glycerol (5%)- Xanthan gum (0.2%)	Glycerol (2%)- Sodium bentonite (0.75%)- Cinnamon oil (2.5%)
Sealing strength	153 to 358 N/m	Not determined	Not determined
Tensile strength	Not determined	48.24 Mpa	0.51 Mpa
Elongation at break	Not determined	27.32 %	72.79 %
Determined	Shelf- life and sealing strength	Mechanical and Antibacterial properties	Mechanical and Antimicrobial properties
Application	Applied only to red chilli powder	Food and Meat industry	Pork meat balls
Reference	Anjum Nawab et al., (2018)	Chandra Mohan et al., (2016)	Butsadee Iamareerat et al (2018)

Conclusion

Due to the impact imposed by the synthetic polymers, green polymers with natural ingredients gained their importance. The edible film made with mango kernel had utilized vastly available agro-waste that had not determined the mechanical properties such as tensile strength, elongation at break and water vapour permeability. An edible film with cassava starch and cinnamon oil has a strong antibacterial property, with its application limited to the packaging of the pork meatball industry. The edible film with tamarind seed starch made up of agro-waste that contains a significant amount of potassium to regulate blood pressure, heart function and reduce hypertension, along with ball-milled spices, are considered to have more natural ingredients with good tensile strength and improved antibacterial properties to enable commercialization in many

food and meat industries. Improvement in its elongation strength and shelf life for various food items can provide a wide application in practice.

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