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A Review On Okra Mucilage Packaging Film As A Sustainable Alternative For Food Packing

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Abstract: In relation to increasing environmental problems over the usage of synthetic plastics, the demand for biodegradable and sustainable packaging materials has beneficial application in recent years. The natural, plant-based films are biodegradable, non-toxic, and even edible, making it an ideal candidate for creating eco-friendly packaging solutions. This study virtues developing and characterizing quality of edible packaging films derived from okra (Abelmoschus esculentus) mucilage, which is a natural polysaccharide having initial film-forming capabilities. The film formulations carry varying plasticizer concentrations which enhance mechanical and barrier properties regarding production of sustainable packaging film. Okra mucilage is a key component in the development of edible films for food packaging applications. The unique properties of okra such as its ability to retain moisture and form strong, flexible films, make it a viable alternative to conventional packaging materials. The use of Okra mucilage to enhance the film's mechanical strength, barrier properties, and resistance to microbial growth is beneficial and adequate idea to overcome challenges such as improving durability and scaling up production and potential benefits of reducing plastic waste, food preservation, sustainable alternative. This review provides a comprehensive look at how okra mucilage could play a crucial role in the future of sustainable, edible packaging.

***Index Terms* - Okra mucilage, edible packaging film, biodegradable material, food packaging.**

I. Introduction

In response to growing environmental concerns related to synthetic plastic packaging, researchers have actively focused on sustainable and biodegradable alternatives(1). Among these, edible packaging films made from natural polymers have garnered significant interest due to their eco-friendly characteristics, compatibility with food, and potential to enhance food preservation. Such materials present a promising solution for reducing plastic waste while maintaining the quality and safety of packaged goods(2,3).

Okra mucilage, a natural polysaccharide extracted from the edible okra plant (Abelmoschus esculentus). Okra mucilage has gained attention for its unique physical properties, such as its ability to form strong, flexible films, high water retention capacity, and its biodegradability(4). These characteristics make okra mucilage an ideal candidate for the development of sustainable, edible films that could serve as alternatives to conventional plastic packaging(5).

Okra is well known for its distinctive mucilage, a thick, gelatinous substance found in the seed pods. Mucilage is a type of soluble fiber composed of polysaccharides, which, when cooked, gives okra its characteristic slimy texture. This mucilage plays an important role in the culinary and nutritional properties of okra. In dishes like gumbo and stews, the mucilage helps thicken the broth, providing a smooth, velvety consistency(6,7).

The mucilage in okra has also been studied for its potential health benefits. It is believed to aid in digestion by acting as a natural lubricant, making it easier for food to pass through the digestive system. Additionally, mucilage can help regulate blood sugar levels, making it beneficial for people with diabetes. Its high fiber content contributes to improved gut health by promoting regular bowel movements(8).
Beyond its nutritional value, okra mucilage has industrial applications, including in cosmetics and pharmaceutical products, where its thickening and emulsifying properties are utilized. Overall, the mucilage in okra is not only a key factor in its culinary appeal but also offers a variety of health and practical benefits(9).

Edible packaging films are innovative materials made from natural, food-safe substances that can be consumed along with the food they protect. They serve as an alternative to traditional plastic packaging, which contributes to environmental pollution(10). These films can be made from a variety of biodegradable ingredients, such as starches, proteins, lipids, and polysaccharides, which are naturally occurring in food.

The primary goal of edible packaging is to reduce the environmental impact of non-biodegradable packaging materials while providing functional benefits such as moisture retention, extending shelf life, and enhancing product presentation. These films can be used to package a wide range of products, from fresh produce to processed foods, and they often have additional properties like antimicrobial effects, which help in preserving food quality(11).

1.2 Key features of edible packaging films include:

1. **Biodegradability**: They break down naturally, reducing waste.
2. **Edibility**: They are safe for consumption and often made from food-grade materials.
3. **Sustainability**: They offer an eco-friendly alternative to plastic packaging.
4. **Functional Benefits**: Edible films can protect food from contamination, improve shelf life, and even offer flavors or nutrients.

Edible packaging films are still in the early stages of widespread adoption but are gaining attention due to the growing concern over plastic waste and the increasing demand for sustainable food packaging solutions(12).
The study highlights potential applications of okra mucilage films in food preservation, emphasizing their role in extending shelf life and maintaining food quality. The review also identifies key challenges in commercializing these films, such as scalability, cost-effectiveness, and regulatory considerations, while proposing future research directions to enhance their practical implementation. By synthesizing recent advancements in the field, this study contributes to the ongoing development of sustainable packaging solutions that align with global initiatives to minimize plastic pollution. The findings emphasize the potential of okra mucilage as a renewable and biodegradable alternative, paving the way for innovative and environmentally responsible food packaging strategies(13).

II.History:

2.1. Early Uses of Okra Mucilage

Okra (Abelmoschus esculentus) is a widely cultivated vegetable known for its mucilaginous properties. Traditionally, okra mucilage has been used in various industries, including food, medicine, and textiles, due to its thickening, emulsifying, and film-forming abilities. Historically, it has been used in traditional medicine for its potential health benefits and as a natural stabilizer in soups and sauces(14).

The history of edible packaging films dates to ancient times when natural materials like leaves were used to wrap food. In the 20th century, research into starch, gelatin, and protein-based films began to explore their potential as food packaging(15). By the 1970s and 1980s, scientists developed protein-based edible films to preserve food, and in the 1990s, there was growing commercial interest as environmental concerns over plastic waste increased. Innovations in the 2000s focused on improving the strength and functionality of edible films, using materials like starch, lipids, and seaweed-based polymers. Today, edible packaging is seen as a sustainable alternative to plastic, with ongoing research into new materials and applications for food and other industries(16).

Okra mucilage, a plant-based polymer composed of polysaccharides and proteins, has emerged as a sustainable alternative to synthetic plastics for packaging. Researchers began exploring its potential in the early 21st century due to its ability to form flexible, biodegradable, and edible films. By the 2010s, studies focused on enhancing its mechanical, barrier, and biodegradability properties, often blending it with biopolymers like starch, alginate, and chitosan(17). Recent advancements, including the incorporation of natural additives like essential oils and nanoparticles, have improved the films' durability and functionality. Today, okra mucilage-based films are being explored for applications such as fresh produce packaging, meat wrapping, and biodegradable food coatings, aligning with sustainability goals(18,19).

2.2. CHARACTERIZATION OF OKRA MUCILAGE EDIBLE FILMS

- **Physical Properties: -** Thickness, transparency, color, and water vapor permeability.
- **Mechanical Properties: -**Tensile strength, elongation at break, and flexibility.
- **Chemical Properties: -** Chemical stability, biodegradability, and interaction with food products.
- **Microstructure: -** Scanning electron microscopy (SEM) or other imaging techniques to study the film's microstructure.
- **Barrier Properties: -** Oxygen and moisture barrier properties to assess the film's effectiveness for food preservation.

III.Application:

1. Cosmetics and Personal Care

Okra mucilage's moisturizing and emollient properties make it valuable in skin and hair care products. It is used in lotions, creams, and moisturizers to hydrate and soothe the skin, as well as in hair conditioners and masks to improve moisture retention, softness, and shine(20).

2. Pharmaceuticals

In the pharmaceutical industry, okra mucilage can be used in controlled drug delivery systems, encapsulating active pharmaceutical ingredients and releasing them gradually. It also shows promise in wound healing, thanks to its natural antimicrobial and antioxidant properties, making it suitable for use in wound dressings and bandages(21).

3. Agriculture

Okra mucilage can be used to create seed coatings that protect seeds from diseases, pests, and environmental stresses, improving germination rates. Additionally, its moisture-retaining abilities can help in soil stabilization, especially in dry or drought-prone areas, improving water retention in soil.

4. Textiles

In the textile industry, okra mucilage can serve as a natural and biodegradable coating or finishing agent. It enhances water resistance and durability of fabrics and can be blended with fibers to create sustainable, biodegradable textiles, reducing environmental impact.

5. Biodegradable Plastics

Okra mucilage is a promising component in developing biodegradable plastic alternatives. It can be used in packaging for non-food items, such as electronics and retail products, as well as in disposable products like utensils, straws, and bags, supporting the reduction of plastic waste.

6. Paper and Pulp Industry

Okra mucilage serves as a natural binding agent in paper production, improving paper strength and flexibility. It can also be applied as a biodegradable coating for paper products, providing an eco-friendly alternative to synthetic coating(22).

7. Biomedical Applications

Okra mucilage is being explored in biomedical fields, particularly in tissue engineering, where it can be used to create scaffolds that support cell growth and regeneration. It also has potential applications for creating biodegradable medical implants or surgical materials.

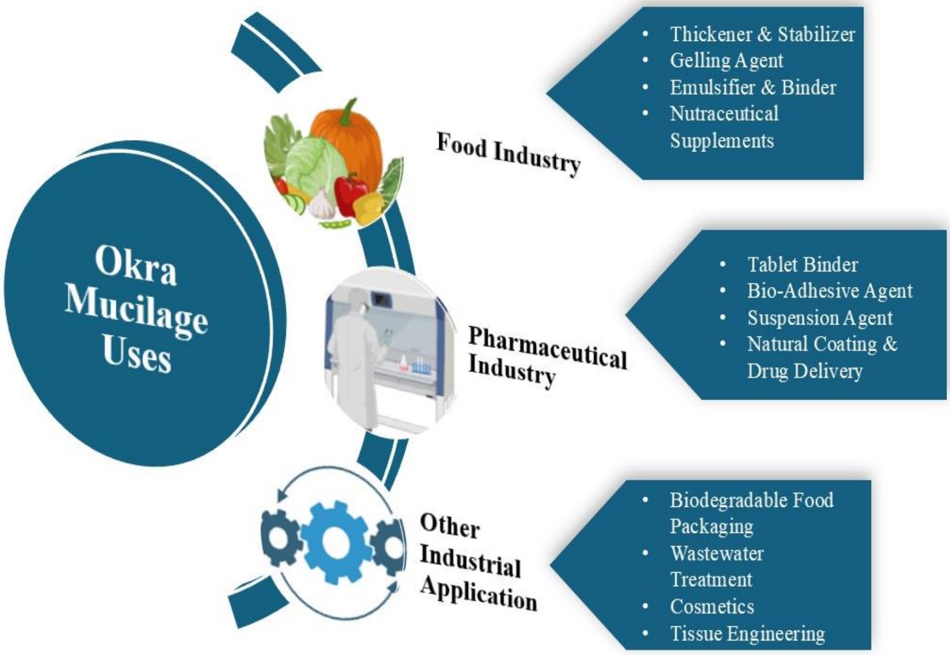

figure1: - uses of okra mucilage

IV.Pharmacological activity:

1. Antioxidant Activity

Okra mucilage contains phenolic compounds, which are known for their antioxidant properties. These compounds help neutralize free radicals, reducing oxidative stress in the body. This activity can contribute to preventing cellular damage, slowing aging processes, and reducing the risk of chronic diseases such as cardiovascular disease and cancer(25).

2. Antimicrobial Activity

Okra mucilage exhibits antimicrobial properties, which make it useful in preventing the growth of harmful bacteria, fungi, and other pathogens. The mucilage has shown potential in controlling the growth of pathogenic microorganisms, thus contributing to food preservation and also offering therapeutic benefits in wound healing by preventing infections(26).

3. Antidiabetic Properties

Okra has been studied for its antidiabetic potential. The mucilage and other components of okra may help regulate blood sugar levels by improving insulin sensitivity and reducing blood glucose levels(27). Okra mucilage may aid in managing diabetes by improving glucose metabolism, which is particularly beneficial in reducing the risk of complications associated with diabetes(28).

4. Wound Healing and Anti-inflammatory Effects

Okra mucilage has shown promise in wound healing due to its anti-inflammatory and antioxidant properties. It promotes faster tissue regeneration and reduces inflammation at the wound site, which can accelerate the healing process. Additionally, its antimicrobial properties prevent infections in wounds, further supporting its role in wound care(31).

5. Gastroprotective Effects

Okra mucilage is known for its gastroprotective effects. It has been found to help soothe the gastrointestinal tract, protect the stomach lining, and reduce symptoms of conditions such as gastritis and acid reflux. The mucilage forms a protective layer on the stomach lining, which may reduce the damaging effects of stomach acid(32,33).

6. Hypolipidemic and Cardioprotective Effects

Okra mucilage and its films have also shown hypolipidemic (cholesterol-lowering) and cardioprotective properties(34,35). Studies suggest that okra may help reduce cholesterol levels in the blood, thereby decreasing the risk of cardiovascular diseases. The antioxidant and anti-inflammatory properties of okra mucilage may further support heart health by protecting the cardiovascular system from oxidative stress(36).

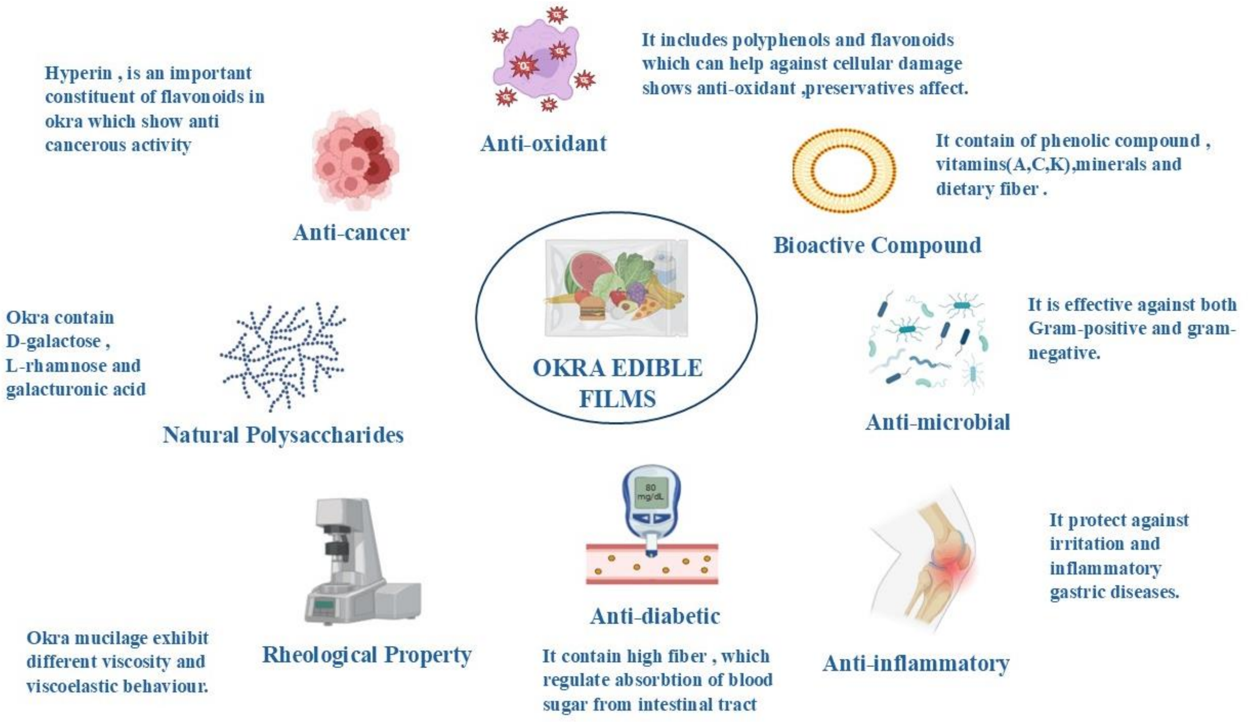

Figure 2: - Pharmacological activity of Edible Films form Okra Mucilage (29,30)

7. Anticancer Activity

Emerging research suggests that okra mucilage may exhibit anticancer properties due to its ability to induce apoptosis (programmed cell death) in cancer cells and inhibit tumor growth(37). The antioxidants in okra mucilage play a role in neutralizing free radicals that contribute to cancer cell formation and progression(38,39).

8. Antiviral Activity

Some studies indicate that okra mucilage may also have antiviral properties, inhibiting the replication of certain viruses. This can have therapeutic potential for viral infections and may be explored in further research as a natural antiviral agent(40).

9. Immunomodulatory Effects

Okra mucilage has been suggested to possess immunomodulatory effects, meaning it can help regulate the immune system. This could be beneficial in strengthening the body's defense against infections and maintaining immune system balance(41).

10. Diuretic Effect

Okra mucilage is believed to have a diuretic effect, which can help in increasing urine production and expelling excess water and waste from the body. This is beneficial for managing conditions like hypertension or fluid retention(42)

Okra mucilage provides a natural, biodegradable, and sustainable alternative to synthetic plastic films(43). However, additional research is necessary to improve extraction techniques, enhance the durability of the films, and ensure that industrial production remains cost-effective. If these challenges are successfully addressed, okra-based edible films could serve as a viable solution for reducing plastic waste in packaging applications(44,45).

V.Benefits:

Benefits Of Okra Mucilage			
Digestive Health	Heart Health	Blood sugar Management	Other Potential Benefits
Soluble Fiber, Nutrient Rich , Support Digestion	Cholesterol Binding, Decrease cholesterol level	Slowed Sugar Absorption	Antioxidant Properties, Anti-inflammatory
Soothing Effect	Decrease the risk of Heart Disease	Potential Antidiabetic Activity	Support Healthy Pregnancy
Regulate Bowel Movements			Enhance vision ,Boost Immune System

VI.Conclusion:

Okra mucilage films provide a promising solution for sustainable, biodegradable, and edible packaging alternatives to traditional synthetic plastics. These films possess key properties such as moisture retention, antimicrobial activity, and antioxidant benefits, making them highly effective for food preservation and extending product shelf life. Research into enhancing their mechanical strength, barrier properties, and biodegradability has led to improved performance, with advances in combining okra mucilage with other biopolymers and natural additives, such as essential oils and nanoparticles.

Okra mucilage films have shown versatility across various applications, from fresh produce packaging to meat wrapping and biodegradable food coatings, offering a functional and eco-friendly alternative to plastic. The ongoing development of these films aligns with the increasing global demand for sustainable packaging materials, making them a viable solution in addressing plastic waste.

As research progresses and production methods improve, okra mucilage films have the potential to become a significant player in the food packaging industry, supporting sustainability and reducing environmental impact. While challenges such as cost and scalability remain, the future of okra mucilage-based edible packaging is promising, with its potential for widespread use in creating a circular economy in packaging.

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