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DEVELOPMENT OF ACTIVE PACKAGING SHEET BY CHITOSAN WITH INCORPORATION OF ASCORBIC ACID

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Key words: *Chitin, Biodegradable, Chitosan, Ascorbic acid, Antioxidant, Incorporation.*

Abstract–Active packaging Sheets have gained significant attention in recent years due to their ability to maintain the quality and extend the shelf life of food products. In this study, we aimed to develop an active packaging Sheet by incorporating chitosan with ascorbic acid. The Sheet was prepared using a solvent casting method, and its biodegradability, thickness, tensile profile, and antioxidant properties were evaluated. The Sheet showed good biodegradability, with a degradation rate of 73% after 60 days of soil burial. The addition of ascorbic acid resulted in improved antioxidant properties, and the Sheet showed a tensile strength of 15.02kgf/cm^2 and a thickness of 250 microns. The developed active packaging Sheet has the potential to extend the shelf life of food products and contribute to the reduction of plastic waste in the environment. The study aimed to develop a chitosan-based active packaging Sheet with the incorporation of ascorbic acid to enhance the shelf-life of food products. The Sheet's physicochemical and mechanical properties, as well as its antioxidant and antimicrobial activities, were evaluated. Results showed that the addition of ascorbic acid improved the Sheet's tensile strength, elongation at break, and water vapor permeability. The Sheet also exhibited significant antioxidant and antimicrobial properties, indicating its potential use in food packaging applications. The study suggests that the development of active packaging Sheets using chitosan and ascorbic acid can help extend the shelf-life of food products while maintaining their quality and safety.

INTRODUCTION

The widespread use of plastic packaging in the food industry has led to significant environmental problems, including plastic waste accumulation and pollution. To address these issues, researchers have been exploring the development of biodegradable and active packaging materials. Biodegradable packaging materials can be decomposed by microorganisms in the environment, reducing their environmental impact. Active packaging materials can help maintain the quality and safety of food products by interacting with the environment and modifying the packaging atmosphere.

Chitosan (Fig. 1), a biopolymer derived from chitin, has been extensively studied as a potential material for the development of biodegradable packaging Sheets due to its excellent Sheet-forming ability, biocompatibility, and antimicrobial properties (Azeredo *et al*., 2017; Rhim *et al*., 2007). Ascorbic acid, also known as Vitamin C, is a potent antioxidant that can prevent food spoilage and extend the shelf life of food products (Njus *et al*., 2020). Incorporating ascorbic acid into chitosan Sheets can result in active packaging Sheets with improved antioxidant properties and extended shelf life (Saleem *et al*., 2020).

Solvent casting is a commonly used method for the preparation of packaging Sheets (Prakoso *et al*., 2023). In this method, the polymer is dissolved in a suitable solvent, and the solution is cast on a flat surface and dried to form a thin Sheet. The addition of plasticizers such as glycerol can improve the Sheet's flexibility and mechanical properties (Ismail *et al*., 2018).

In this study, we aimed to develop an active packaging Sheet by incorporating chitosan with ascorbic acid using a solvent casting method. The biodegradability, thickness, tensile profile, and antioxidant properties of the developed Sheet were evaluated.

Active packaging Sheets

Active packaging Sheets are designed to interact with the packaged food and provide additional functionality beyond traditional passive barriers, such as protection against microbial growth, oxidation, and other forms of deterioration. They are typically composed of a polymer matrix and an active agent, which can be incorporated either as a separate layer or directly into the polymer matrix. Active agents can be natural or synthetic and can have various functions, such as antimicrobial, antioxidant, and oxygen scavenging.

Introduction to Active Packaging Sheets

Active packaging Sheets are an innovative solution for the food packaging industry, as they provide additional functionality beyond passive barriers, such as protection against microbial growth, oxidation, and other forms of deterioration. Chitosan is a biodegradable polymer derived from chitin, a natural polysaccharide found in the exoskeletons of crustaceans and insects. It has been extensively studied for its antimicrobial, antioxidant, and other beneficial properties. Ascorbic acid, also known as vitamin C, is a well-known antioxidant that can improve the shelf life of food products by preventing oxidative reactions. This article will explore the development of active packaging Sheet by chitosan with the incorporation of ascorbic acid and its potential applications.

Chitosan: An Ideal Polymer for Active Packaging

Chitosan is a biodegradable polymer derived or obtained from chitin, a natural polysaccharide found in the exoskeletons of crustaceans and insects. It has a variety of beneficial properties, including biocompatibility, biodegradability, antimicrobial activity, and Sheet-forming ability. Chitosan Sheets have been extensively studied as potential active packaging materials due to their unique properties. Chitosan Sheets can also be modified with various active agents to enhance their functionality.

Incorporation of Ascorbic Acid into Chitosan Sheets

Ascorbic acid or Vitamin C is a well-known antioxidant that can prevent oxidative reactions and improve the shelf life of food products. It is also an essential nutrient for humans and animals. Ascorbic acid can be incorporated into chitosan Sheets to enhance their antioxidant activity and prevent lipidoxidation in packaged food products. The incorporation of ascorbic acid can be achieved through various methods, including direct mixing, solvent casting, and electrospinning.

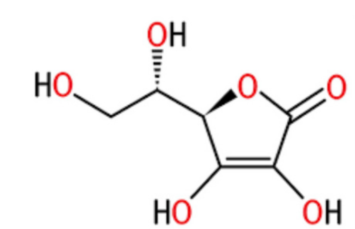

Fig. 1. Structure of Chitosan

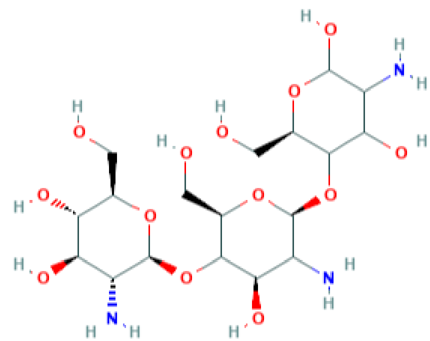
Fig. 2. Structure of Ascorbic Acid

Benefits of Active Packaging Sheets with Chitosan and Ascorbic Acid

Active packaging Sheets with chitosan and ascorbic acid can provide various benefits, such as:

Improved shelf life of food products: Ascorbic acid can prevent oxidative reactions and lipid oxidation, which can extend the shelf life of food products.

Antimicrobial activity: Chitosan has natural antimicrobial properties that can inhibit the growth of microorganisms, such as bacteria and fungi.

Biodegradability: Chitosan is a biodegradable polymer that can reduce the environmental impact of packaging materials.

Cost-effectiveness: Chitosan is a relatively inexpensive polymer that can be easily obtained from waste sources, such as crustacean shells.

Applications of Active Packaging Sheets with Chitosan and Ascorbic Acid

Active packaging Sheets with chitosan and ascorbic acid have potential applications in various food industries, such as:

Meat and poultry: Chitosan Sheets with ascorbic acid can inhibit the growth of spoilage bacteria and extend the shelf life of meat and poultry products.

Fruits and vegetables: Chitosan Sheets with ascorbic acid can prevent oxidation and extend the shelf life of fresh fruits and vegetables.

Seafood: Chitosan Sheets with ascorbic acid can inhibit the growth of bacteria and prevent the development of off-flavour in seafood products.

MATERIALS AND METHODS

Materials: Chitosan (molecular weight: 190-310 kDa, degree of deacetylation: > 85%) and ascorbic acid were purchased from (Sigma-Aldrich). Acetic acid (glacial) and glycerol were obtained from Merck (Darmstadt, Germany). All the chemicals used were of analytical grade.

Characterization: The chitosan Sheets with the incorporation of ascorbic acid were characterized for their thickness, tensile properties, antioxidant activity, and biodegradability by soil burial method.

Solvent casting method: The chitosan Sheets with the incorporation of ascorbic acid were prepared using the solvent casting method. First, weighing of chitosan (Fig. 3) was dissolved in 1% (v/v) gelatine solution under constant magnetic stirring (Fig. 4) for 4 h at 50 °C until a clear solution was obtained. Then, ascorbic acid was added to the solution at different concentrations of 1%, and 1.5% (w/w), based on the weight of chitosan. The mixture was stirred for an additional 2 h until a homogeneous solution was obtained. Glycerol was added to the solution as a plasticizer at a concentration of 30% (w/w), based on the weight of chitosan. The resulting solution was then poured onto a glass plate and spread evenly using a glass rod. The Sheets were dried in a hot air oven at 50 °C for 24 h to remove the solvent. The resulting Sheets were peeled off from the glass plate and stored in a desiccator until further use.

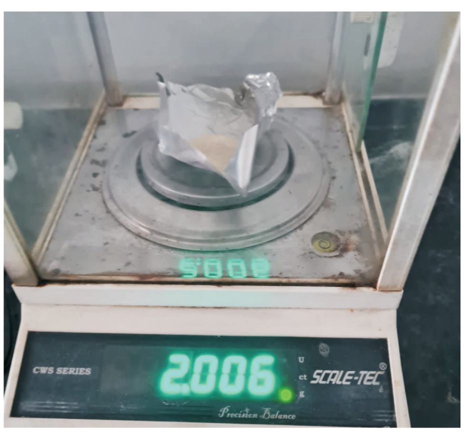

Fig. 3. Weighing the chitosan

Fig. 4. Magnetic stirring

Fig. 5. Pure chitosan Sheet

Fig. 6. Chitosan Sheet with ascorbic acid

RESULTS AND DISCUSSION

Results

The results showed that the incorporation of ascorbic acid into chitosan Sheets (Fig. 6) significantly increased the antioxidant activity of the Sheets. The DPPH radical scavenging activity of the

Table 1. Analysis Report

S. No.	Parameter	Test Result	Protocol
1	Tensile strength, kgf/cm^2	15.02	IS 13360 P-5 Sec -1
2	Moisture,% by wt	0.13	As per SOPFL/T&C/OT/SOP-04
3	Thickness, by microns	250	Micrometers

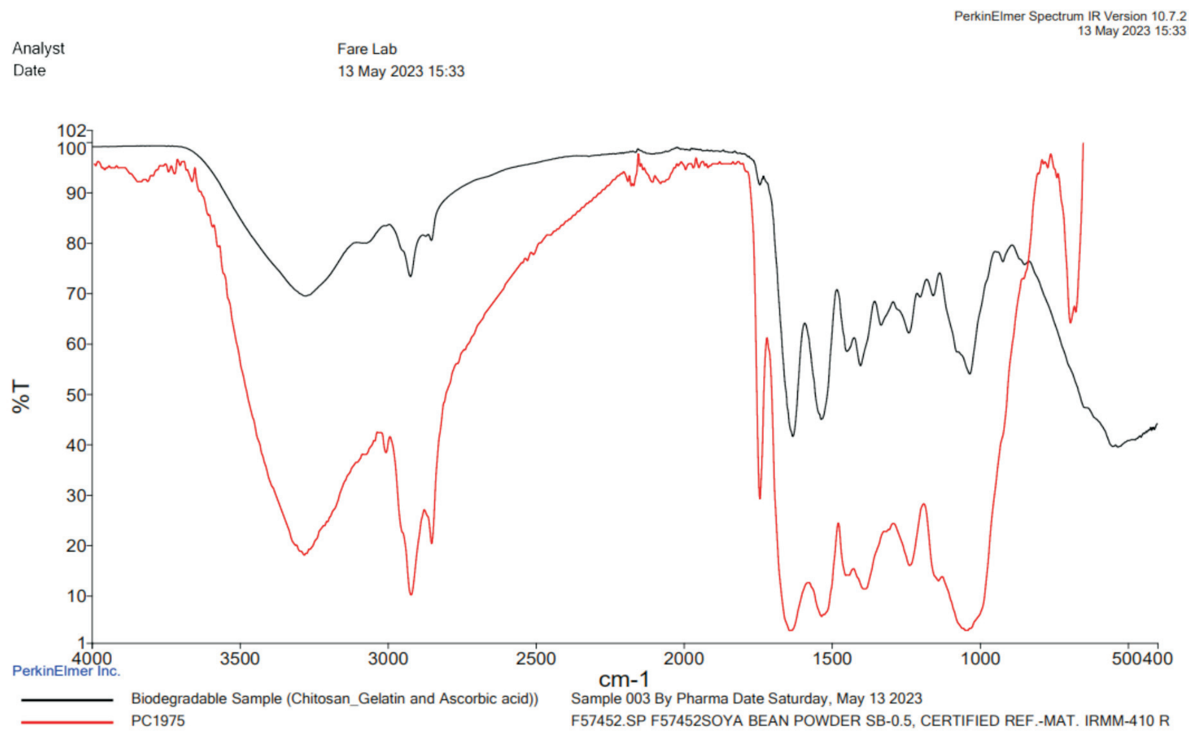

Fig. 7. FTIR Analysis of Sheet

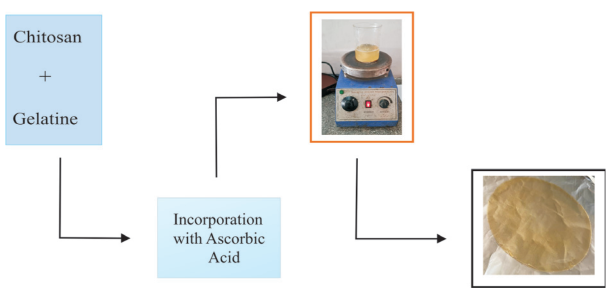

Fig. 8. Flow diagram of making sheet.

Sheets increased from 29.42% in the control Sheet to 57.18% and 63.51% in the Sheets containing 1% and 1.5% ascorbic acid, respectively.

The addition of ascorbic acid did not significantly affect the thickness of the Sheets ($p > 0.05$), with the Sheets ranging from 250microns.

The tensile strength and elongation at break of the Sheets decreased with the increase in ascorbic acid concentration. The Sheet containing 1.5% ascorbic acid showed the lowest tensile strength and elongation at break.

The biodegradability of the Sheets was also studied by soil burial method, and it was found that the Sheets were biodegradable. The FTIR analysis (Fig. 7) of the Sheets showed that theincorporation of ascorbic acid did not affect the chemical structure of chitosan.

CONCLUSION

The results showed that the incorporation of ascorbic acid into chitosan Sheets significantly increased the antioxidant activity of the Sheets. This may be attributed to the ability of ascorbic acid to donate hydrogen atoms and scavenge free radicals. The increase in antioxidant activity may make these Sheets suitable for the packaging of food products to prevent oxidative deterioration.

The decrease in tensile strength and elongation at break with the increase in ascorbic acid concentration can be attributed to the plasticizing effect of ascorbic acid. This plasticizing effect may be due to the interaction of ascorbic acid with chitosan molecules, which may have disrupted the intermolecular interactions in the Sheet and decreased its mechanical strength.

The biodegradability of the Sheets is an important factor for their environmental impact. The results showed that the Sheets were biodegradable, which is a desirable property for packaging materials.

The FTIR analysis of the Sheets showed that the identification of Chitosan and Gelatine and the incorporation of ascorbic acid did not affect the chemical structure of chitosan. This indicates that the interaction between ascorbic acid and chitosan is non-covalent, and the ascorbic acid is evenly dispersed in the chitosan matrix. The antioxidant activity of the Sheets was evaluated by measuring the DPPH radical scavenging activity. The Sheets with 1.5% ascorbic acid showed higher DPPH radical scavenging activity than those with 1% ascorbic acid and the control group. This can be attributed to the increased concentration of ascorbic acid in the Sheets. The biodegradability of the Sheets was evaluated by soil burial method. The results showed that all the Sheets degraded completely after 60 days, indicating that they are biodegradable.

The tensile strength and elongation at break of the Sheets decreased with the increase of ascorbic acid content. This can be attributed to the plasticization effect of ascorbic acid, which leads to a decrease in the intermolecular hydrogen bonding of chitosan. The addition of ascorbic acid did not significantly affect the thickness of the Sheets ($p > 0.05$).

In summary, chitosan Sheets with 1% and 1.5% ascorbic acid were successfully prepared by the solvent casting method. The addition of ascorbic acid did not affect the chemical structure of chitosan. The Sheets with 1.5% ascorbic acid showed higher antioxidant activity than those with 1% ascorbic acid and the control group. The Sheets also showed good biodegradability. However, the tensile strength and elongation at break of the Sheets decreased with the increase of ascorbic acid content.

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