

EXPERIMENTAL INVESTIGATION ON THE INFLUENCE OF PROCESSES PARAMETERS ON THE FILM PROPERTIES OF STARCH BASED EDIBLE FILMS

Submitted in partial fulfilment of the requirements for the award of
Bachelor of Engineering degree in Mechanical Engineering

By

GOBISANKAR V (Reg. No. 39150706)

CHIDAMBARA KANNAN A (Reg. No. 39150024)



DEPARTMENT OF MECHANICAL ENGINEERING

SCHOOL OF MECHANICAL ENGINEERING

SATHYABAMA

INSTITUTE OF SCIENCE AND TECHNOLOGY

(DEEMED TO BE UNIVERSITY)

**Accredited with grade “A” by NAAC | 12B Status by UGC | Approved by AICTE
JEPPIAAR NAGAR, RAJIV GANDHI SALAI, CHENNAI – 600119**

MAY 2023



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DEPARTMENT OF MECHANICAL ENGINEERING 2023

BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of **GOBISANKAR V (39150706)** and **CHIDAMBARA KANNAN A (39150024)** who carried out the project entitled **Experimental investigation on the influence of processes parameters on the film properties of starch based edible films** under our supervision from June 2022 to May2023

Internal Guide

Dr. V. SRIRAM, M.E., Ph.D.,

Head of the Department

Dr. G. ARUNKUMAR, M.E., Ph.D.,

Submitted for Viva voce Examination Held on 10.05. 2023

Internal Examiner

External Examiner

DECLARATION

We, **GOBISANKAR V** and **CHIDAMBARA KANNAN A**, hereby declare that the Project Report entitled Experimental analysis on effect of nanoparticles over the thermal characteristics of heat pipes done by us under the guidance **Dr. Sriram M.E., Ph.D.**, at Sathyabama Institute of Science and Technology is submitted in partial fulfilment of the requirements for the award of Bachelor of Engineering degree in Mechanical Engineering.

DATE:

1)



PLACE: Chennai

2)



SIGNATURE OF THE CANDIDATES

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ABSTRACT

Edible alive Films show individual of the current and future flows in the incident of new polymers for picked uses, specifically bread bundle. Some biopolymers show wonderful efficiency as warships for alive factors that are came from open beginnings and at a regulated rate maybe freed in bundle snack. In this review, we aim to supply a inclusive survey of new advances and amends on this field, that is now the subject of much research and very repeatedly stated new studies. This report focuses on creative biopolymer models, their dispose of into succulent alive films, and current and future uses. Incorporation of plasticizers, lie of multilayer, composites, and nanocomposite films considerably upgraded the features, but few elementary research on the key determinants debris expected surveyed. Current workshop scale result of succulent films has questions, to a degree failure to produce constant films, long drying periods, and vague denseness control that must be tried superior to monetary-scale result. Lack of evidence on security, biodegradability, strength and toxicological belongings, immoral shopping, lack of knowledge, enlightening issues can influence meal security and services agreement. Future research must address all these questions from the view of industrialized growth and marketing facets. To produce industrially possible and commercially profitable tasty films

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CHAPTER 1

INTRODUCTION

Edible film packaging refers to a type of food packaging made from edible materials that are safe for human consumption. These materials can include starches, proteins, and lipids that are formed into a thin, transparent film. Edible film packaging has gained popularity as an alternative to traditional non-edible packaging materials because it is environmentally friendly and biodegradable. Edible films can be used to package a variety of foods, including fresh produce, meat, dairy, and snacks. The films can provide a barrier to moisture and oxygen, which can help to extend the shelf life of the food inside. They can also be used to improve the appearance of the food, such as by adding a glossy finish or enhancing the color. One of the advantages of edible film packaging is that it can reduce the amount of waste generated by traditional non-edible packaging materials. Since the film is edible, it can be consumed along with the food, eliminating the need for separate disposal. Additionally, edible films can be produced using renewable resources, making them more sustainable than petroleum-based plastics. However, there are also some challenges associated with edible film packaging. One of the main challenges is maintaining the stability and integrity of the film during storage and transportation, as the films can be susceptible to moisture and temperature fluctuations. Additionally, there may be concerns regarding the safety and hygiene of the films, particularly if they are not produced in a controlled environment.

1.1 TYPES OF PROCESS IN EDIBLE FILMS

Edible films are thin layers of material that are consumed along with the food product. They can be made from different materials such as proteins, polysaccharides, and lipids. The type of process used to produce edible films varies. Some common types of processes used to produce edible films include:

- **Casting:** This process involves pouring a solution of film-forming material onto a plain area and allowing it to dry to form a thin film. The resulting film can be peeled off and used for various applications.
- **Extrusion:** In this process, the film-forming material is forced through a small

opening to create a thin film. This process can be used to create films of varying thickness and can be used for both hot and cold extrusion.

- Coating: Coating involves applying a layer of film-forming material onto a food product using a variety of methods such as dipping, brushing. This process for fruits and vegetables to enhance their shelf life.
- Compression molding: This process involves compressing a mixture of film-forming material and plasticizer between two heated plates to create a thin film. This process is commonly used for producing films from thermoplastic materials.
- In this process, a solution of film-forming material is mixed with a cross-linking agent to form a gel. The gel is then dried a thin film. This process for producing films from polysaccharides. the material used, and the desired physical and chemical properties of the film.

1.2 DRY PROCESS

Edible films are thin layers of edible material that are used to enclose or cover food items. They are often used as a packaging material for foods and appearance of the food. There are several dry processes for producing edible films, including:

- Compression molding: This process involves pressing a powdered or granulated form of the edible material into a mold at high pressure and temperature. The resulting film can be removed from the mold and trimmed to the desired size and shape.
- Extrusion: In this process, the edible material is melted and forced through a die to form a continuous sheet or tube. The sheet or tube is then cooled and cut to the desired size and shape.
- Spray drying: This process involves atomizing a solution or dispersion of the edible material into a spray dryer, where the droplets are dried by hot air. The resulting powder can be reconstituted with water to form a film.
- Electrospinning: This process involves applying a high voltage to a solution or dispersion of the edible material, causing it to form a fine, fibrous web. The web can be collected and used as a film.

These dry processes offer advantages such as scalability, cost-effectiveness, and versatility, making them attractive options for producing edible films. Potato starch dry film processes involve the use of potato starch to create a thin, transparent film that can be used as edible packaging material. The process can be broken down into the following steps: Mixing: The potato starch is mixed with water or other ingredients, such as glycerol or sorbitol, to create a smooth, homogenous solution. Heating: The mixture is heated to a specific temperature to activate the potato starch and create a viscous solution. Casting: The viscous solution is then poured onto a flat surface, such as a conveyor belt or a glass plate, and spread into a thin, even layer. Drying: The potato starch film is then dried in a hot air dryer or oven until it is completely dry and stiff. Conditioning: Once dry, the potato starch film is conditioned by exposing it to a specific temperature and humidity to improve its mechanical and barrier properties. Cutting: The potato starch film is then cut into the desired size and shape for packaging. Potato starch films produced through this process have several advantages over traditional packaging materials. They are biodegradable, compostable, and edible, reducing the amount of waste generated by traditional packaging materials. They can also provide a barrier to moisture and oxygen, which can help to extend the shelf life of the food inside. Additionally, they can improve the appearance of the food and add value to the product. However, there are also some challenges associated with the use of potato starch films for packaging. The films can be susceptible to moisture and temperature fluctuations, which can affect their stability and integrity. Additionally, the cost of producing potato starch films can be higher than traditional packaging materials, which can limit their adoption. Overall, potato starch films offer a promising solution to the growing problem of plastic waste in the packaging industry.

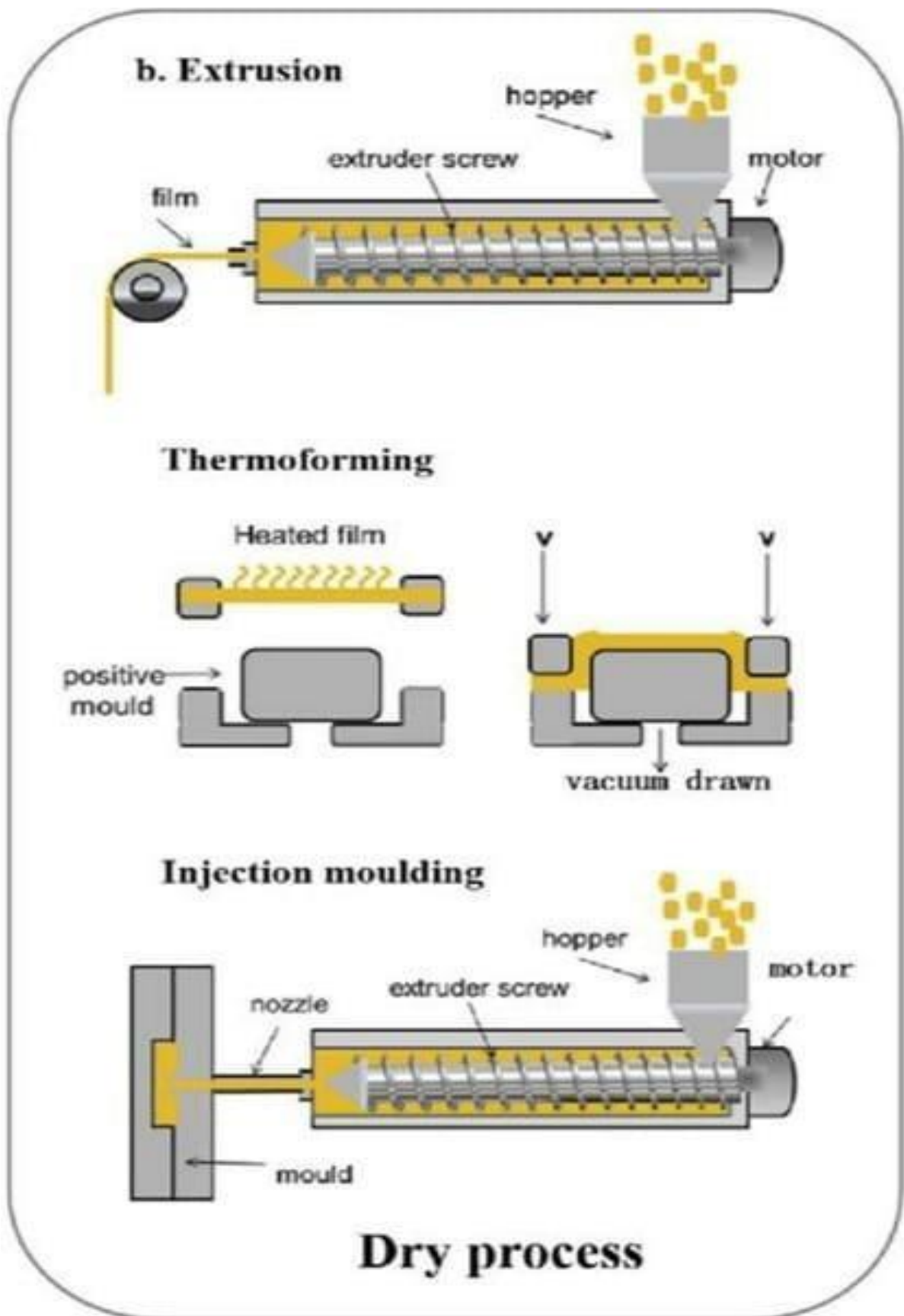


Fig: 1.1: Dry Process



Fig: 1.2: Dry Processes Stage 1



Fig: 1.3: Dry Processes Stage 2

1.3 PROCESSES OF EXTRUSION

The process involves melting the edible material and forcing it through a die to form a continuous sheet or tube. Here are the steps involved in the extrusion process for edible film production:

Material preparation: The edible material is first chosen, and its formulation is optimized for extrusion. This includes selecting the type and amount of ingredients to use, such as film-forming agents, plasticizers, and colorants.

Mixing and heating: The ingredients are mixed in a batch mixer or extruder and melting point of the material.

Extrusion The heated material is fed into an extruder with a conformed shape and size. The die can be shaped into a flat sheet or a tube. The extruder applies high pressure to force the material through the die, creating a continuous film.

Cooling and solidifying: After extrusion, the film is cooled rapidly using chilled rollers or air. The rapid cooling helps to prevent shrinkage and distortion of the film. The film is then solidified by cooling to room temperature or below.

Trimming: The solidified film is trimmed to the desired size and shape using a cutting device, such as a rotary cutter or a guillotine.

Further processing: The film can be subjected to further processing, such as laminating, coating, or printing, to improve its performance and appearance.

Extrusion is a continuous process that offers several advantages, including high production rates, consistent film quality, and easy control of film thickness. The process can also accommodate a wide range of edible materials and produce films with various properties, such as flexibility, strength, and barrier properties.

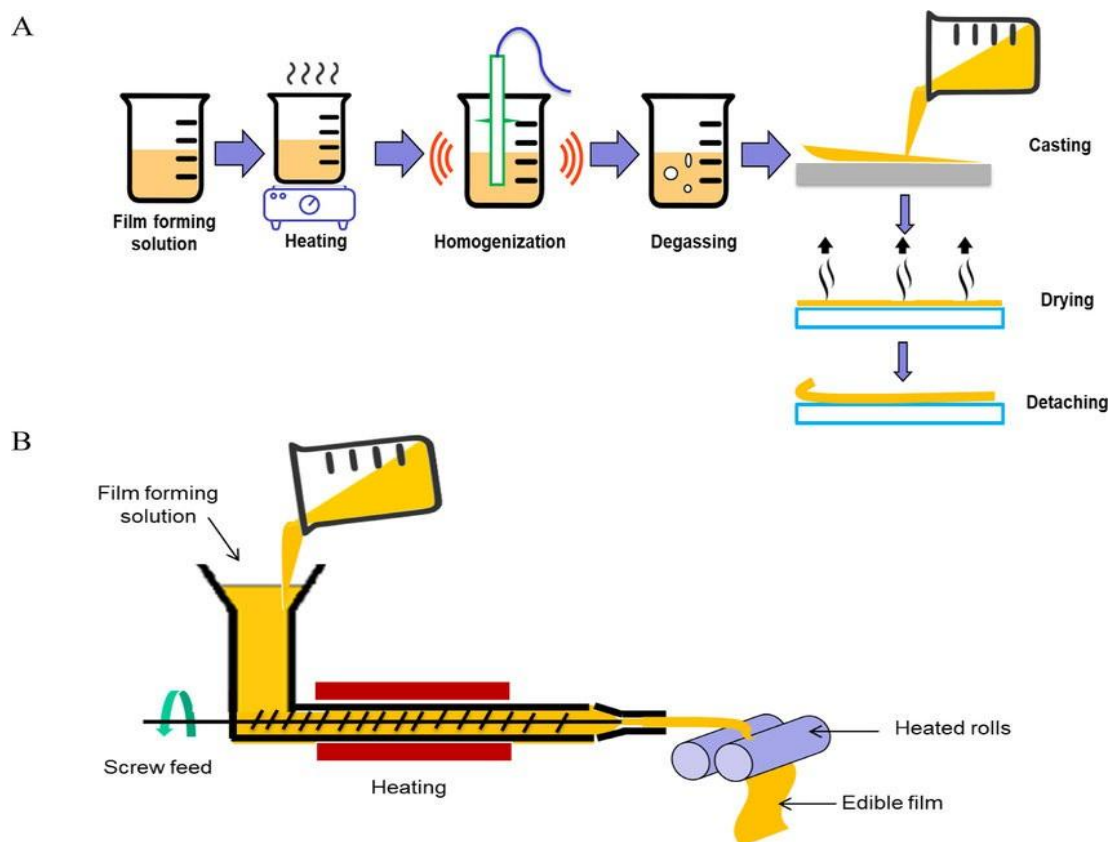


Fig: 1.4: Extrusion

1.4 INJECTION MOLDING

- Injection molding is a manufacturing process in which molten material is injected into a mold cavity to form a solid object. The process is also used for producing edible films. Here are the steps involved in the injection molding process for edible film production:
- Material preparation: The edible material is first chosen, and its formulation is optimized for injection molding. This includes selecting the type and amount of ingredients to use, such as film-forming agents, plasticizers, and colorants.
- Mixing and heating: The ingredients are mixed in a batch mixer or extruder
- Injection molding: The heated material is injected into a mold cavity under high pressure using an injection molding machine. The mold can be shaped into a flat sheet or a tube. The molten material fills the mold cavity, taking the shape of the mold and solidifying into a film.

- **Cooling and solidifying:** After injection molding, the film is cooled rapidly using chilled water or air. The rapid cooling helps to prevent shrinkage and distortion of the film. The film is then solidified by cooling to room temperature or below.
- **Ejection and trimming:** The solidified film is ejected from the mold cavity and trimmed to the desired size and shape using a cutting device, such as a rotary cutter or a guillotine.

The film can be subjected to further processing, such as laminating, coating, or printing, to improve its performance and appearance. Injection molding is a precise and repeatable process that offers several advantages, including high production rates, consistent film quality, and easy control of film thickness. The process can also accommodate a wide range of edible materials and produce films with various properties, such as flexibility, strength, and barrier properties. However, the process requires specialized equipment and molds, making it more expensive than other methods of producing edible films.

Potato starch injection molding is a process used to create biodegradable and compostable products, such as food containers and packaging materials. The process involves the following steps:

Mixing: Potato starch is mixed with water and other ingredients, such as plasticizers and processing aids, to create a homogenous solution.

Heating: The mixture is then heated to a specific temperature and pressure, typically between 140°C and 200°C, to melt the starch and create a viscous liquid.

Injection molding: The molten potato starch is injected into a mold cavity under high pressure, where it cools and solidifies to form the desired shape.

Ejection: The finished product is then ejected from the mold cavity and prepared for distribution.

Potato starch injection molding has several advantages over traditional plastic injection molding. It is a sustainable and environmentally friendly process that creates biodegradable and compostable products. Additionally, it requires less energy to produce than traditional plastic injection molding and can be cost-effective in the long run. However, there are also some challenges associated with potato starch injection molding. The process can be more difficult to control than traditional plastic injection molding, as potato starch can be sensitive to variations in temperature and humidity. Additionally, the

mechanical properties of potato starch-based products can be weaker than traditional plastic products, which can limit their suitability for certain applications.

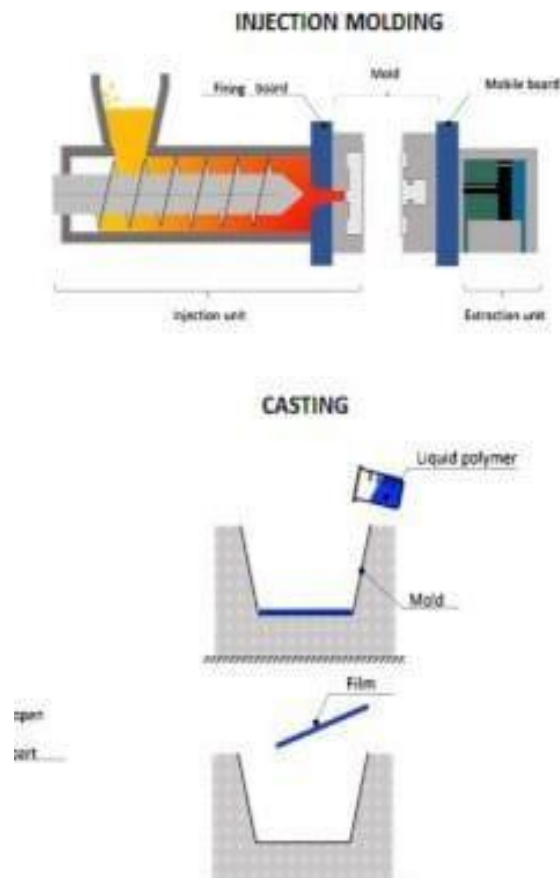


Fig: 1.5: Injection Molding

1.5 Wet Process

rich film wet processes involve the use of starch to create a thin, transparent film that can be used as packaging material. The wet process can be broken down into the following steps:

1. **Mixing:** Starch is mixed with water or other solvents to create a slurry or solution.
2. **Heating:** The mixture is heated to a specific temperature, typically between 60°C and 100°C, to gelatinize the starch and create a viscous solution.
3. **Casting:** The viscous solution is then poured onto a flat surface, such as a glass plate, and spread into a thin, even layer.
4. **Drying:** The starch film is then dried in a hot air dryer or oven until it is completely dry and stiff.

5. Conditioning: Once dry, the starch film is conditioned by exposing it to a specific temperature and humidity to improve its mechanical and barrier properties.
6. Cutting: The starch film is then cut into the desired size and shape for packaging.

Starch films produced through the wet process have several advantages over traditional packaging materials. They are biodegradable, compostable, and edible, reducing the amount of waste generated by traditional packaging materials. They can also provide a barrier to moisture and oxygen, which can help to extend the shelf life of the food inside. Additionally, they can improve the appearance of the food and add value to the product. However, there are also some challenges associated with the use of starch films for packaging. The films can be susceptible to moisture and temperature fluctuations, which can affect their stability and integrity. Additionally, the cost of producing starch films can be higher than traditional packaging materials, which can limit their adoption. There are several wet processes for making edible films, including: Casting: This process involves pouring a liquid mixture of film-forming materials onto a flat surface, such as a glass plate, and allowing it to dry. The resulting film can then be peeled off and used as a coating or packaging material. Extrusion: In this process, a viscous mixture of film-forming materials is forced through a small opening, forming a continuous film. The film can be shaped by passing it through rollers or other shaping devices. Coagulation: This process involves adding a film-forming material, such as gelatin or casein, to a liquid bath. When the film-forming material comes into contact with the liquid, it coagulates and forms a film. Emulsification: In this process, a film-forming material is emulsified in a liquid to form a stable mixture. The mixture is then spread out and dried to form a film. Solvent casting: This process involves dissolving a film-forming material in a solvent and then casting the solution onto a flat surface. The solvent is then evaporated, leaving behind a thin film. These processes can be used to create a variety of edible films with different properties, such as thickness, texture, and strength. The choice of process will depend on the specific application and the desired characteristics of the final product.

1.6 SOLUBLE CASTING

Casting is a manufacturing process in which a liquid material is usually poured into a mold and then solidified. Easy to use, inexpensive and environmentally friendly, the casting process could also be used to produce biopolymer films. Chitosan-gelatin film-forming solutions could use the solution casting method to produce chitosan-gelatin composite films. During the casting process, equipment, atmosphere, time, and temperature can significantly affect the performance of the final films. The casting process typically involves three procedures, including casting, drying, and balanced storage. Soluble casting is a wet process for making edible films that involves dissolving a film-forming material in a suitable solvent and then casting the solution onto a flat surface. The solvent is then evaporated, leaving behind a thin film. This process is also known as the "solvent-casting" method. The film-forming materials used in soluble casting can vary widely and can include proteins, polysaccharides, lipids, and their derivatives. Some common examples of film-forming materials used in edible film production include gelatin, chitosan, pectin, and cellulose derivatives. The solvent used for soluble casting should be a good solvent for the film-forming material, but it should also be safe for consumption and easy to remove. Common solvents used in edible film production include water, ethanol, glycerol, and acetic acid. The main advantage of the soluble casting process is its ability to produce uniform films with precise thickness and excellent mechanical properties. The resulting films are also transparent and have good barrier properties against moisture, oxygen, and other gases. However, the soluble casting process has some limitations, including the use of solvents that can be costly or difficult to remove, and the potential for the film-forming material to degrade or lose its properties during the casting process. Overall, the soluble casting process is a useful method for producing edible films food industry.

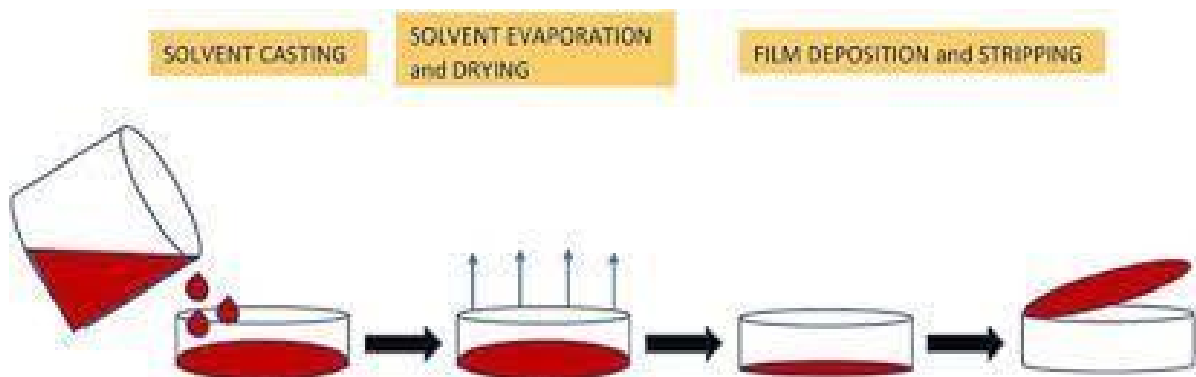


Fig: 1.6: Solution Casting

1.7 TAPE CASTING

tarch tape casting is a process used to create thin, flat sheets of starch for various applications such as packaging, paper products, and biodegradable films. The process involves the following steps:

1. **Mixing:** Starch is mixed with water or other solvents to create a slurry or solution.
2. **Casting:** The solution is then cast onto a flat surface, such as a glass plate or a stainless-steel belt, using a doctor blade or a roll coater.
3. **Drying:** The starch sheet is then dried in a hot air dryer or oven until it is completely dry and stiff.
4. **Conditioning:** Once dry, the starch sheet is conditioned by exposing it to a specific temperature and humidity to improve its mechanical and barrier properties.
5. **Cutting:** The starch sheet is then cut into the desired size and shape for further processing or use.

Starch tape casting has several advantages over traditional methods of creating thin, flat sheets of materials. It is a low-cost and environmentally friendly process that creates biodegradable and compostable products. Additionally, it allows for precise control over the thickness and properties of the starch sheet, making it suitable for a wide range of applications. However, there are also some challenges associated with starch tape casting. The process can be sensitive to variations in temperature and humidity, which can affect the quality of the starch sheet. Additionally, the mechanical properties of starch-based products can be weaker than traditional plastic products, which can limit their suitability for certain applications. Tape casting is a common method for producing thin and uniform films, and it can also be used for producing edible films. Edible film tape casting involves the deposition of a film-forming material in a thin and uniform layer onto a substrate using a doctor blade or a similar device. The resulting film can then be peeled off and used as a coating or packaging material.

The tape casting process typically involves the following steps:

- Preparation of the film-forming material: The film-forming material is prepared as a liquid or a suspension in a suitable solvent. The material is then mixed to ensure homogeneity and consistency.
- Substrate preparation: A substrate is chosen, such as a glass or metal plate, and cleaned to ensure that it is free of any contaminants.
- Application of the film-forming material: The film-forming material is deposited onto the substrate using a doctor blade or similar device.
- Drying: The film is allowed to dry at room temperature or at a controlled temperature and humidity to ensure uniformity.
- Peeling off the film: Once the film is dry, it is carefully peeled off the substrate for packaging material.

The edible film produced by tape casting can have precise thickness and excellent mechanical properties. It can also be made from a wide range of film-forming materials, including proteins, carbohydrates, lipids, and their derivatives. The tape casting process is also versatile and can be used for producing edible films with different properties, such as transparency and water vapor permeability.

However, the tape casting process has some limitations, such as the potential for defects in the film due to uneven deposition or drying. Overall, edible film tape casting is a useful method for producing high-quality, thin, and uniform edible films.

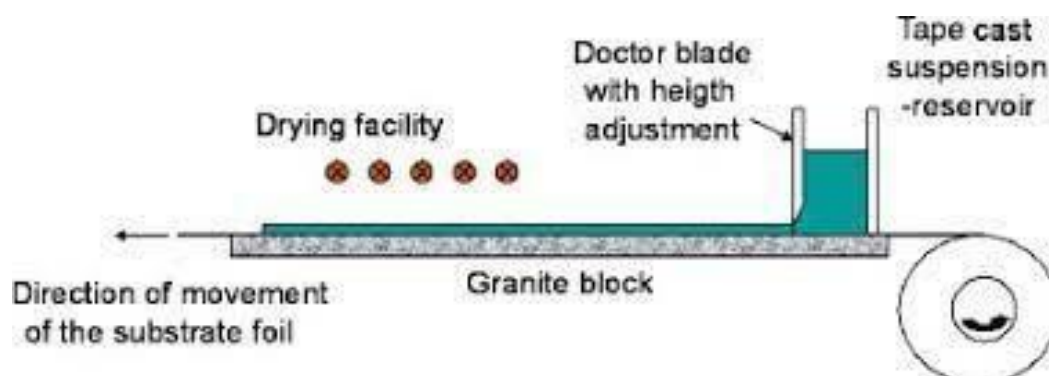


Fig: 1.7: Tape Casting

CHAPTER 2

LITERATURE SURVEY

The article by Mir et al. (2018) discusses the effect of plant extracts on the techno-functional properties of biodegradable packaging films. The study aimed to develop biodegradable packaging films using plant extracts as additives and evaluate their mechanical, barrier, and thermal properties. The researchers used four different plant extracts, namely turmeric, green tea, mint, and rosemary, and incorporated them into a biodegradable polymer matrix to prepare the packaging films. The properties of the films were then evaluated using various techniques. The results showed that the addition of plant extracts improved The barrier properties of the films, including water vapor and oxygen permeability, were also improved by the addition of plant extracts. Furthermore, the thermal stability of the films was enhanced with the addition of plant extracts.

Atarés and Chiralt (2016) published an article entitled "Essential oils as additives in biodegradable films and coatings for active food packaging. The article discusses the use of essential oils as additives in biodegradable films and coatings for active food packaging. The authors review the properties and applications of essential oils and their potential use as natural additives to improve the functional properties of biodegradable packaging materials. The article provides an overview of the different techniques used to incorporate essential oils into biodegradable films, such as emulsification, solvent casting, and extrusion. The authors also discuss the effects of essential oils on the mechanical, barrier, and antimicrobial properties of the packaging materials. The study concludes that essential oils can be effective natural additives for improving the use of essential oils in packaging materials could potentially lead to the development of more sustainable and eco-friendly packaging options for the food industry.

The article by Lazaridou and Biliaderis (2020) entitled "Edible films and coatings with pectin" is a chapter in the book "Pectin: Technological and Physiological Properties."The chapter discusses the use of pectin, a natural polysaccharide, in the

development of edible films and coatings for food applications. The authors of pectin, including its chemical structure, gelation properties, and interactions with other food components. The study highlights the advantages of using pectin in edible films and coatings, including its biodegradability, low cost, and ability to form gels and films with desirable mechanical and barrier properties. The authors also discuss the factors that influence the properties of pectin-based films and coatings, such as pH, temperature, and the presence of other additives. The article concludes by discussing the potential applications of pectin-based films and coatings in the food industry, including their use of edible packaging food items, as coatings for bakery products, and as carriers for bioactive compounds. The authors also suggest areas for future research processing conditions and the evaluation of their environmental impact.

The article "Edible films from chitosan-gelatin: Physical properties and food packaging application" by Wang et al. (2021) published in the journal Food Bioscience, explores the use of chitosan-gelatin edible films for food packaging applications. The study focuses on the development and characterization of edible films made from a combination of chitosan and gelatin; two natural polymers commonly used in food applications. The physical properties of the films, including mechanical strength, water vapor permeability, and transparency, as well as their potential as food packaging materials. The results showed that the addition of gelatin to chitosan improved the mechanical properties of the films, such as tensile strength and elongation at break, while maintaining good transparency. The films also exhibited low water vapor permeability, indicating their potential as effective barriers against moisture. In addition, the authors tested the potential of the chitosan-gelatin films as packaging materials for fresh strawberries and found that they were effective in maintaining the quality and extending the shelf life of the fruit. Overall, the study suggests that chitosan-gelatin films have potential as a sustainable and effective alternative to traditional plastic packaging materials for food applications.

The article "Enhancing the properties of gelatin-chitosan bionanocomposite films by incorporation of silica nanoparticles" by Batra et al. (2020) published in the Journal

of Food Process Engineering, investigates the use of silica nanoparticles to improve the properties of gelatin-chitosan bionanocomposite films. The study investigates the authors evaluated the mechanical, thermal, and barrier properties of the films with and without the addition of silica nanoparticles. The results showed that the incorporation of silica nanoparticles into the bionanocomposite films significantly improved their tensile strength, elastic modulus, and thermal stability indicating their potential as effective barriers against moisture. The study concludes that the addition of silica nanoparticles could be a promising approach.

The article "Evaluation of wool nanoparticles incorporation in chitosan/gelatin composite films" by Eslahi et al. (2014) published in the Journal of Applied Polymer Science, explores the use of wool nanoparticles in chitosan-gelatin composite films. The study investigates shows wool nanoparticles as a potential additive to improve the properties of composite films made from chitosan and gelatin, two natural The authors evaluated the mechanical, thermal, and barrier properties of the composite films with and without the incorporation of wool nanoparticles. The results showed that the addition of wool nanoparticles to the composite indicating their potential as effective barriers against moisture. The study concludes that the incorporation of wool nanoparticles could be a promising approach to improve the properties of composite films made from chitosan and gelatin. These films have potential as biodegradable alternatives to traditional plastic packaging materials for food applications. However, further studies are needed to investigate the potential toxicity of wool nanoparticles and their impact on food safety.

The article "Preparation, physicochemical and biological evaluation of quercetin-based chitosan-gelatin film for food packaging" by Yadav et al. (2020) published in the journal Carbohydrate Polymers, investigates the use of quercetin, a natural antioxidant, in chitosan-gelatin films for food packaging applications. The study focuses on the development and characterization of chitosan-gelatin films incorporated with quercetin, a natural antioxidant commonly found in fruits and vegetables. The authors evaluated the physicochemical and biological properties of the films, including mechanical strength, water vapor permeability, antioxidant activity, and antimicrobial activity, to determine their potential as food packaging

materials. The results showed that the addition of quercetin to the chitosan-gelatin films improved their mechanical properties, antioxidant activity, and antimicrobial activity against common foodborne pathogens such as *Escherichia coli* and *Staphylococcus aureus*. The films also exhibited low water vapor permeability, indicating their potential as effective barriers against moisture.

The article "Shelf-life extension and quality attributes of sauced silver carp fillet: A comparison among direct addition, edible coating, and biodegradable film" by Rezaei and Shahbazi (2018) published in the journal *LWT - Food Science and Technology*, compares the effectiveness of direct addition, edible coating, and biodegradable film in extending the shelf life and preserving the quality of sauced silver carp fillet. The study aimed to evaluate the effectiveness of different preservation methods, including direct addition of preservatives, edible coating, and biodegradable film, in extending the shelf-life and maintaining refrigerated storage. The authors evaluated the physicochemical and microbiological properties of the fillet samples over a period of 15 days, including pH, color, texture, lipid oxidation, and microbial growth. The results showed that all three preservation methods were effective in extending the shelf-life of the fillet samples compared to the control group (no preservation). However, the edible coating and biodegradable film methods were found to be more effective than direct addition in maintaining the quality attributes of the fillets, including texture, color, and lipid oxidation.

CHAPTER 3

AIM AND SCOPE

3.1 AIM:

- The first aim is to prepare the edible film for food packaging.
- The second aim is to test the properties of the prepared films.

3.2 SCOPE

Edible film packaging is a rapidly growing field of research that aims to provide a sustainable and environmentally friendly alternative to traditional plastic packaging. The main scope of edible film packaging is to develop packaging materials that can be consumed along with the product, reducing waste and environmental impact. The main aim of edible film packaging is to: Reduce plastic waste: Traditional plastic packaging is a major contributor to plastic pollution. Edible film packaging aims to reduce this pollution by providing an alternative that can be consumed or decomposed naturally. Improve food safety: Edible films can act as a barrier to prevent contamination of food products, improving their safety and shelf life. Enhance product quality: Edible films can improve appearance, flavor, and texture of food products, improving their overall quality. Support sustainable agriculture: Edible films can be made from natural and renewable sources such as starch, cellulose, and protein. This supports sustainable agriculture and reduces the dependence on non-renewable resources. Promote circular economy: Edible films can be made from food waste or by-products, promoting a circular economy where waste is transformed into a valuable resource. Overall, the aim and scope of edible film packaging is to develop sustainable, safe, and high-quality packaging solutions that can reduce environmental impact and support a circular economy.

CHAPTER 4

MATERIALS AND METHODS

4.1 MATERIALS

Edible films can be used to coat or package food products. The choice of edible film material and method will depend on the specific application and the desired characteristics of the final product. Edible film materials can include natural polymers such as proteins, carbohydrates, and lipids, as well as synthetic polymers such as polyvinyl alcohol and polyethylene glycol. Some common edible film materials include: Gelatin: a protein-based film that is transparent and has good water vapor barrier properties. Chitosan: a carbohydrate-based film that is antimicrobial and has good mechanical properties. Cellulose derivatives: a class of polysaccharides that can be used to produce films with different properties such as transparency and water vapor permeability. Lipids: a class of materials that can be used to produce films with good water vapor barrier properties and oxidative stability. The methods used to produce edible films can be divided into dry and wet processes. Dry processes involve the formation of films from a pre-formed solid, while wet processes involve the formation of films from a liquid or solution. Some common methods for producing edible films include: Casting: a wet process that involves pouring a liquid mixture of film-forming materials. Resulting film can then be peeled off and used as a coating or packaging material. Extrusion: a wet process that involves forcing a viscous mixture of film-forming materials through a small opening, forming a continuous film. Compression molding: a dry process that involves pressing pre-formed film-forming materials into a mold and heating them to form a solid film. Solvent casting: a wet process that involves dissolving a film-forming material in a solvent and then casting the solution onto a flat surface. The solvent is then evaporated, leaving behind a thin film. Overall, the choice of edible film material and method will depend on the specific application and the desired properties of the final product, such as transparency, water vapor permeability, and mechanical strength.

4.2 MECHANICAL PROPERTIES

The mechanical properties of these films are an important consideration when selecting a film-forming material and a production method. The mechanical properties of edible films can affect their ability to protect food products from external factors such as moisture, oxygen, and light.

Some of the key mechanical properties of edible films include:

- **Tensile strength:** This is the maximum stress that a film can withstand before it breaks. The tensile strength of edible films is important for determining their ability to resist deformation or tearing.
- **Elongation at break:** This is the maximum percentage of deformation that a film can undergo before it breaks. The elongation at break of edible films is important for determining their flexibility and stretchability.
- **Young's modulus:** This is a measure of the stiffness of a material. The Young's modulus of edible films is important for determining their ability to resist deformation under a load.
- **Water vapor permeability:** This is a measure of the ability of a film to allow water vapor to pass through it. The water vapor permeability of edible films is important for determining their ability to protect food products from moisture.

The film-forming material and the production method used. For example, films made from protein-based materials such as gelatin tend to have lower tensile strength and higher elongation at break compared to films made from carbohydrate-based materials such as chitosan. Additionally, the mechanical properties of edible films can be improved through the addition of plasticizers or crosslinking agents. Overall, the mechanical properties of edible films are important for determining their ability to protect food products and maintain their quality during storage and transportation.

4.3 WATER AND LIPID SOLUBILITY

Water vapor permeability and liquid solubility are important properties of edible films that determine their effectiveness as barriers to moisture and other liquids. Water vapor permeability (WVP) is a measure of the ability of a film to allow water vapor to pass through it. A lower WVP indicates that the film is a better barrier to moisture.

The WVP film-forming material, and processing conditions. Generally, films made from hydrophobic materials such as lipids have lower WVP than films made from hydrophilic materials such as proteins or carbohydrates. However, the addition of plasticizers or crosslinking agents can improve the WVP of edible films. Liquid solubility is a measure of the ability of a film to dissolve or disintegrate when in contact with a liquid. The liquid solubility of edible films is important for determining their suitability as coatings for foods that contain liquid or moist ingredients. Films made from hydrophilic materials such as proteins or carbohydrates have higher liquid solubility than films made from hydrophobic materials such as lipids. The addition of crosslinking agents or modifying the film-forming material can reduce the liquid solubility of edible films. It is important to balance the water vapor permeability and liquid solubility of edible films to ensure that they effectively protect the food product while maintaining their structural integrity. Factors such as the intended use of the edible film, the type of food product being coated, and the expected storage conditions should be considered when selecting the film-forming material and processing conditions for edible films.

4.4 POTATO STARCH

Potato starch is a fine white powder that is extracted from potatoes. It is a type of carbohydrate that is commonly used as a thickener in cooking and baking. Potato starch is also used as a binder and stabilizer in a variety of processed foods, such as soups, sauces, and baked goods. Potato starch is generally considered safe to consume in moderate amounts as a part of a healthy diet. However, excessive consumption may lead to digestive issues such as bloating, gas, and diarrhea. When it comes to edible potato starch, it is important to note that not all potato starch is created equal. Some potato starch may be treated with chemicals or other substances during the manufacturing process, which could be harmful if ingested in large quantities. It is important to choose potato starch that is labeled as "food-grade" or "edible" to ensure that it is safe for consumption. If you have any concerns about consuming potato starch, it is always best to consult with a healthcare professional or a registered dietitian.



Fig.4.1: Potato Starch

4.5 GLYCEROL

Food grade edible glycerol, also known as glycerin or glycerine, is a clear, odorless, and viscous liquid that is commonly used as a food additive. It is classified as a sugar alcohol and has a sweet taste. Glycerol is widely used in the food industry as a humectant, solvent, and sweetener. It can be found in many products, including baked goods, dairy products, confectionery, beverages, and processed foods. Glycerol is generally recognized as safe by the U.S. Food and Drug Administration when used in accordance with good manufacturing practices. It is also approved for

use in the European Union as a food additive. It is important to note that while glycerol is safe for consumption, excessive intake can lead to gastrointestinal discomfort and diarrhea. Therefore, it is recommended to consume it in moderation.



Fig: 4.2: Glycerol

4.6 BLENDING

Blending glycerol at 70 degrees Celsius is possible, but it depends on the specific application and the type of glycerol being used. Glycerol has a high boiling point of 290 degrees Celsius, so it can withstand high temperatures without boiling off. However, it is important to note that the viscosity of glycerol increases with temperature, which may make it more difficult to blend or mix with other ingredients at higher temperatures. In some cases, heating glycerol may also cause it to oxidize and degrade over time, which can affect its quality and stability. If you are planning

to blend glycerol at 70 degrees Celsius, it is important to use appropriate mixing equipment and techniques to ensure thorough blending and minimize any potential degradation. It is also important to follow any safety guidelines and regulations for handling glycerol and other chemicals at high temperatures. A stirrer hot plate is a laboratory instrument that combines heating and stirring functionalities. It is commonly used in chemistry and biology experiments that require precise temperature control and constant mixing of substances. The stirrer hot plate consists of a flat heating surface with a magnetic stir bar placed on it. The stir bar is turned by a magnetic field generated by an electromagnet located beneath the surface. The hot plate provides heat to the substance being mixed, while the stirring motion ensures that the temperature is evenly distributed throughout the solution. Stirrer hot plates come in various sizes and shapes, and some can be equipped with additional features such as digital temperature control, programmable stirring speed, and safety features such as overheat protection and spillage resistance. Stirrer hot plates are commonly used in microbiological studies. They are also widely used in educational laboratories, where they provide a safe and reliable way for students to learn about basic laboratory techniques.



Fig :4.3: Blending



Fig: 4.4: before blending



Fig: 4.5: After blending

4.7 HALOGEN LIGHT

Halogen lamps operate at a high temperature compared to other types of lamps. The filament inside a halogen lamp can reach temperatures of up to 2,500 degrees Celsius (4,532 degrees Fahrenheit), which is much higher than the temperature of a typical incandescent bulb. The high temperature is necessary for the halogen cycle to work, which allows the halogen gas to combine with the evaporated filament material and redeposit it back onto the filament. The heat also causes the filament to emit a bright, white light that is similar to natural sunlight. Because of their high operating temperature, halogen lamps require special care when handling, and it is important to avoid touching the bulb with bare hands as the oils from the skin can weaken the bulb and reduce its lifespan. It is also essential to make sure that the lamp is properly ventilated to avoid overheating, and that it is not used in a location where it may come into contact with flammable materials.



Fig: 4.6: Halogen Light

4.8 VACCUM PUMP

A vacuum desiccator is not typically used directly in edible films, but it may be used as a tool to help prepare and store materials used in the production of edible films. Edible films are thin layers of food-grade materials that can be used to wrap or coat food products. They are often made from natural polymers such as proteins or carbohydrates, and may be used to improve food safety, freshness, or appearance. In the production of edible films, the moisture content of the materials is a critical factor that can affect the film's properties and quality. A vacuum desiccator may be used to dry and store the materials used in the production of edible films, such as proteins or carbohydrates, prior to their use in film formation. By removing moisture from these materials, the vacuum desiccator can help to ensure that the films are uniform and have the desired mechanical properties. In addition, a vacuum

desiccator can be used to store the edible films after production, to prevent moisture uptake and preserve their quality. such as those made from proteins, which can become brittle or lose their elasticity when exposed to high humidity.



Fig: 4.7: Vaccum Pump

CHAPTER 5

RESULTS AND DISCUSSION

5.1 FILM THICKNESS

Film thickness refers to the measurement of the distance between the top and bottom surfaces of a thin film. The thickness of a film can be measured in various units, including micrometres (μm), nanometres (nm), or Angstroms ($\text{\AA}$). The thickness of a film is a critical parameter that can affect the properties and performance of the film. For example, in the case of thin films used in electronic devices, film thickness can affect the electrical conductivity, optical properties, and mechanical strength of the film. In the case of coatings or barriers, film thickness can affect properties such as permeability, adhesion, and durability. The measurement of film thickness can be performed using various techniques, including profilometry, ellipsometry, optical interferometry, and scanning electron microscopy. The choice of technique depends on factors such as the thickness range of the film, the desired precision and accuracy of the measurement, and the surface characteristics of the film. Overall, film thickness is an important parameter to consider in many applications, as it can impact the functionality and performance of the film. (0.156),(0.151),(0.153).



Fig:5.1: Thickness of Film

5.2 FILM COLOUR

Film colour can vary depending on the type of film and its intended application. Films can be transparent, translucent, or opaque, and can come in a variety of colours, including clear, white, black, and various shades of gray, blue, green, and red. The color of a film can be influenced by a variety of factors, including the material used to make the film, the additives added to the film, and the manufacturing process used to produce the film. For example, pigments or dyes may be added to the film to create specific colours or to enhance the film's stability or other properties. The color of a film can also affect its performance. For example, films that are highly transparent or translucent may be used to allow light to pass through, while opaque films may be used to block light or provide privacy. In some cases, films may be designed to change color under specific conditions, such as with temperature or exposure. Overall, the color of a film is an important consideration in its selection and application, as it can impact the film's appearance, functionality, and performance. Film color can be tested using various methods, depending on the specific application and desired information. Here are some common techniques for testing film color: Visual inspection: The simplest method is to visually inspect the film for color and clarity. This can be done by holding the film up to a light source or against a white background. Spectrophotometry: Spectrophotometry measures the amount of light absorbed or transmitted by a sample at different wavelengths. This method can provide quantitative information about the color and transparency of the film. Colorimetry: Colorimetry measures the color of a sample based on the perceived color by the human eye. This method can provide information about the hue, saturation, and brightness of the film color. Microscopy: Microscopy can be used to examine the surface or cross-section of a film to observe the color and any color variations or defects. Thermal analysis: Some films may change color or discolor under high-temperature conditions. Thermal analysis can be used to determine the temperature at which color changes occur.



Fig: 5.2: Test 1



Fig:5.3: Test Reading 1



Fig:5.4: Test Reading 2

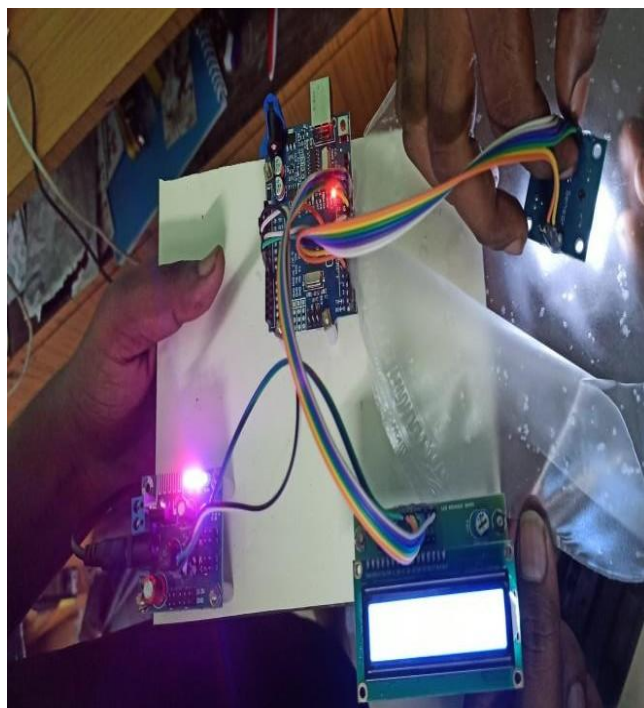


Fig:5.5: Test Reading 3

5.3 MECHANICAL STRENGTH

Mechanical strength is an important property of edible films, as it determines their ability to withstand stresses and strains during handling, packaging, and storage. The mechanical strength of an edible film can be characterized by various parameters, including tensile strength, elongation at break, puncture resistance, tear strength, and flexural strength. Tensile strength is the maximum stress that a film can withstand before breaking when it is stretched. Elongation at break is the degree of stretch before the film breaks. Puncture resistance is the force required to penetrate the film with a sharp object, while tear strength is the force required to tear the film apart. The mechanical strength of an edible film can be influenced by various factors, including the type and concentration of the film-forming material, the presence of plasticizers, and the processing conditions used to produce the film. For example, adding plasticizers to the film-forming solution can increase the flexibility and elongation at break of the film, while increasing the concentration of film-forming material can increase the tensile strength.

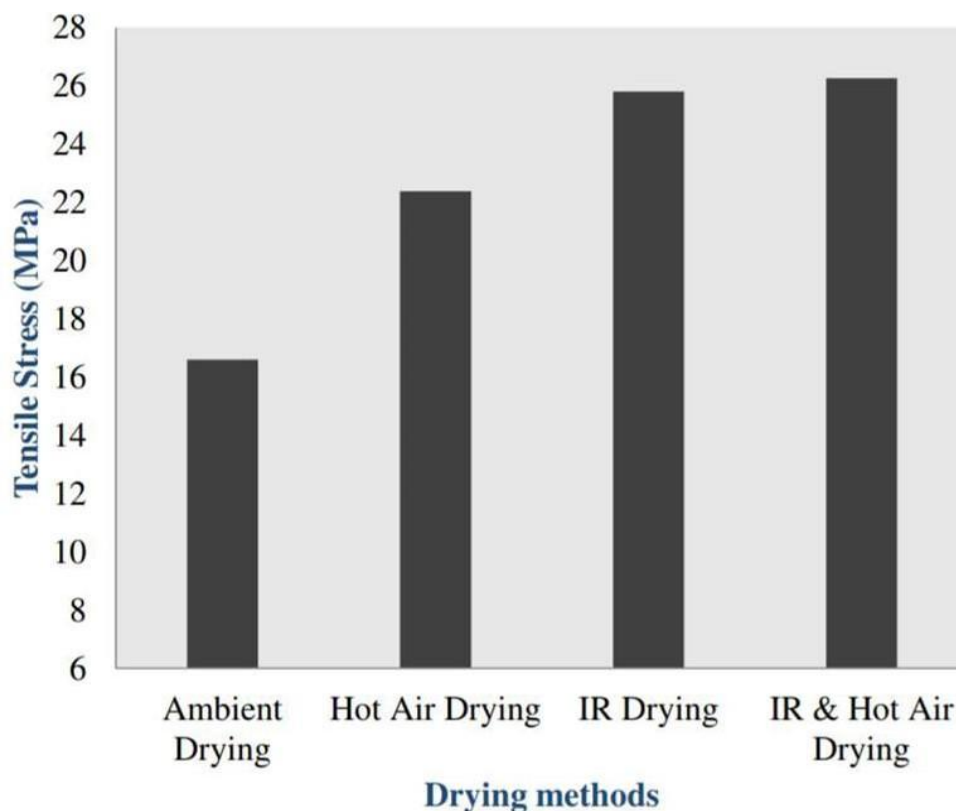


Fig:5.6: Tensile Strength

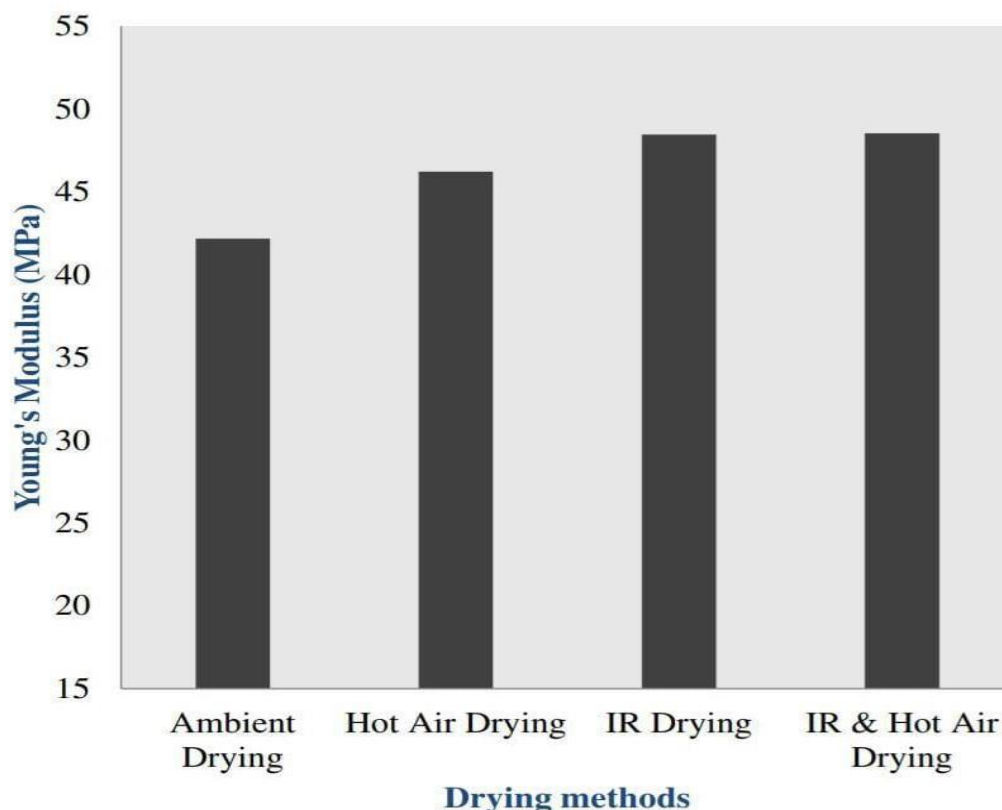


Fig:5.7: Youngs Modules

5.4 WATER VAPOUR TRANSMIT RATE

Water vapor transmission rate (WVTR) is an important property of edible films, as it affects the film's ability to control moisture transfer and maintain the quality and shelf life of the food product. The WVTR of an edible film can be characterized by the rate at which water vapor passes through the film under specific conditions, typically in grams per square meter per hour ($\text{g/m}^2/\text{h}$). The WVTR of an edible film can be influenced by various factors, including the type and concentration of film-forming material, the presence of plasticizers, and the processing conditions used to produce the film. For example, adding plasticizers can increase the flexibility and WVTR of the film, while increasing the concentration of film-forming material can decrease the WVTR. The WVTR of an edible film can be measured using various methods, including gravimetric methods, such as ASTM E96, and other more advanced techniques such as coulometric, infrared and gas chromatography methods. In food packaging applications, the WVTR of an edible film is an important

consideration, as it can impact the film's ability to protect the food product from moisture loss or gain, as well as from spoilage and microbial growth. For example, films with low WVTR are often used to protect moisture-sensitive foods, such as fresh produce, while films with high WVTR are used to allow for the release of excess moisture from certain food products, such as cheese or meats. Overall, the WVTR of an edible film is an important property to consider in its selection and application, as it can affect the quality and shelf life of the food product.

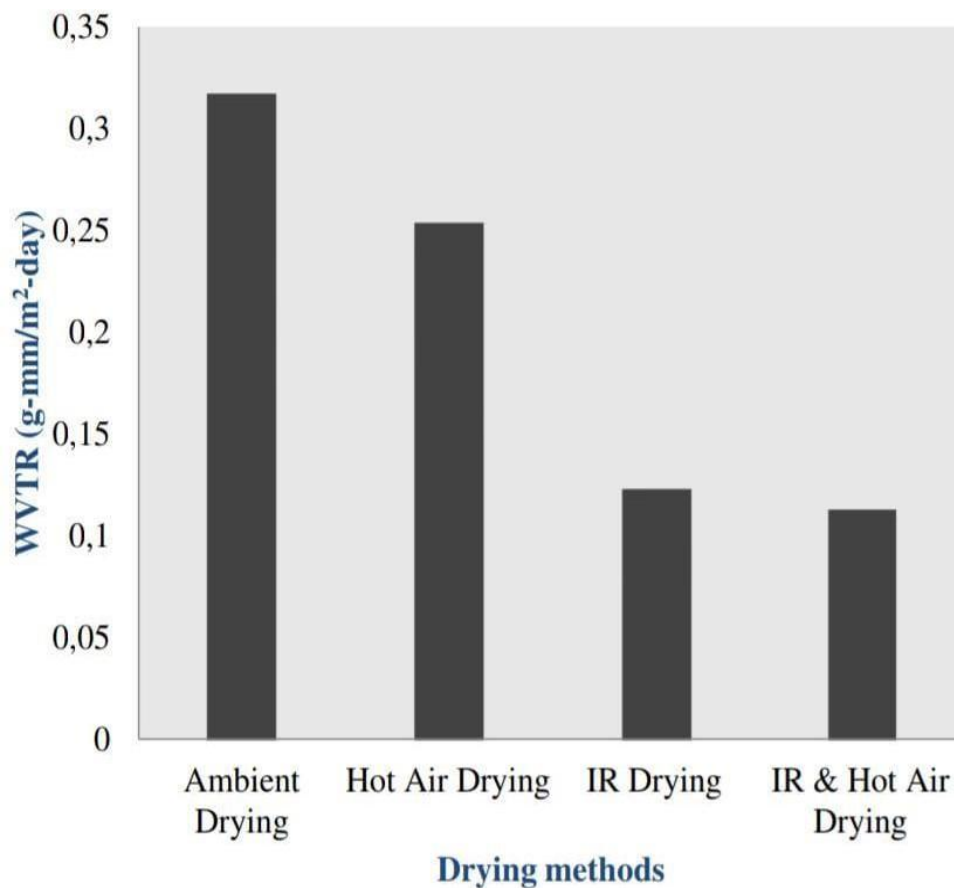


Fig :5.8: Water Vapour Transmit Rate

CHAPTER 6

CONCLUSION

In conclusion, edible films are a promising alternative to traditional packaging materials, as they offer various benefits, including biodegradability, sustainability, and compatibility with food products. Edible films can create difference of natural materials, such as proteins, polysaccharides, and lipids, and can be tailored to specific applications by adjusting their composition and processing conditions. Edible films offer several functional properties, including mechanical strength, water vapor transmission rate, which make them suitable for various food packaging applications. Edible films to enhance the sensory and nutritional properties of food products, such as by incorporating antioxidants or flavor compounds. However, there are still some challenges to overcome in the development and commercialization of edible films for food packaging. These include issues related to shelf life, cost-effectiveness, and scalability of production. Additionally, there are regulatory considerations related to the safety and labeling of edible films as food packaging materials. Overall, edible films have the potential to revolutionize food packaging by offering a more sustainable and eco-friendly option that also enhances the quality and safety of food products. With ongoing research and development, edible films are likely to become a more common option for food packaging in the future.

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