

Original Research Article

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Edible Beta Glucan Based Biopolymer Sheet Preparation-its Antimicrobial Characterization Studies

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ABSTRACT

Biopolymers based food grade additives and their applications constantly increasing in food and medical industries. Polysaccharides are an indispensable component of many foods. Digestible polysaccharides are a good source of calories and glucose needed for normal metabolic process in the body. It was concluded that Beta glucan with optimization was estimated with 0.450mg/20 ml only extraction yield was estimated as 0.20mg/20ml. This showed optimization could improve the yield of beta glucan from *Saccharomyces cerevisiae*. Also, the polymer sheet texture, elasticity and durability found more suitable.

Introduction

An increasing demand for ready to eat food products with a long shelf-life lead to extend towards revolution in food packaging. Unwanted blends of microplastics contamination and associated health risk factors due to commercial synthetic packaging have raised an insight for the need for edible biopolymers. Such edible polymers are the polymeric materials which can be readily consumed by human beings or lower animals in whole or part via the oral cavity and given harmless effect to the health. Simultaneously maintaining the packaged food product quality is also possible.

Natural polymers and food grade additives have become increasingly popular in the medical and food industries. Polysaccharides, proteins, and lipids, as well as

plasticizers and surfactants, can be used to make edible polymers. The ability of edible polymers is primarily determined by their barrier, mechanical, and color properties, which are influenced by the film composition and production procedure. The moisture barrier performance of polysaccharide-based films is typically below, but they exhibit selective O₂ and CO₂ permeability and oil resistance (Costa et al., 2015).

In the past years, the food industry has employed a lot of edible films made from polysaccharides (cellulose, starch, pectin, seaweed, gums, chitosan, and pullulan), but lignocellulosic materials have just recently been shown to be viable for making edible films. Edible films may operate as transporters of active substances, such as antioxidants, antimicrobials, and texture enhancers (Acevedo et al., 2015).

Edible films can be fabricated based on cellulose, starch (natural and modified), pectin, seaweed extracts (alginates, carrageenan, and agar), gums (acacia, tragacanth, and guar), pullulan, and chitosan (Sanchez-Ortega *et al.*, 2014). Films are made harder, crisper, more compact, viscous, sticky, and capable of producing gels; other significant sources of polysaccharide-based biomaterial have been regarded as marine creatures, such as seaweed, bacteria, and microalgae. Moreover, edible polymers needed to meet a variety of requirements in order to be used as packaging and food components, including high barrier and mechanical efficiency, biochemical, physicochemical, and microbiological stabilities, as well as being nontoxic, nonpolluting, and inexpensive (Bergo *et al.*, 2010).

Many efforts have been made to create eco-friendly packaging material in response to the challenges caused by plastic waste in the packaging business. Food packaging is critical for storing foods, protecting them from infection, and maintaining food quality throughout the packaging to consumption process. Several types of plastics are being used as packaging material due to their low cost, high performance, and easy production. Almost half of the packaging materials used in single use throwaway applications, particularly food packaging, are produced from petrochemical polymers, such as plastics (Hopewell *et al.*, 2009). Efforts should also be made to reduce or eliminate the applications of chemically synthesized additives for food storage.

However, petrochemical plastics have a number of drawbacks, including environmental challenges, health dangers, and poor food quality due to their non-biodegradability (Filho *et al.*, 2020). Also, production and consumption of plastics in last few decades has put enormous stress on the environment by releasing plastics waste. Thus, there is a need to look for alternative packaging materials that should not impose any problems, renewable, disposable, recyclable, and easily degradable (Cutter *et al.*, 2006). A thin coating that covers the food surface is known as an edible package.

Edible polymers can be taken whole or in part by humans and lower animals through the oral cavity, with no negative health effects. Many advantageous properties, such as non-pollutant products, since they contain natural and biodegradable components generated from both natural and manmade materials are considered. Edible polymers have emerged as a suitable candidate for food packaging applications and have received significant

attention in recent years (Shit *et al.*, 2014). It is comprised in any of the four categories: Hydrocolloids, polypeptides, lipids, synthetic and composite edible polymers. In the 21st century, an interest in food formulations containing complex polysaccharides continues to rise, owing to the bioactivities and health promoting functions of these polysaccharides (Lamothe *et al.*, 2019).

With the advancements in research, β -glucans have been identified from microbial sources (Ahmed, A, *et al.*, 2018) as well as from some mushrooms, lichens, and seaweed/algae. β -glucan occurs widely in the cell wall of these microorganisms (bacteria, fungi, yeast) and in the endospermic and aleuronic walls of the cereal grains (oats, barley, rye and millets). β -glucan is a non starch polysaccharide composed of Beta-D-glucose monomer units holding a glycosidic linkage at Beta (1-3), (1-4), and (1-6), and either in a branched or in an unbranched manner (Ahmed. A and Kaleem. M., 2018). Hence in this study starch based polymer combinations made to improve biopolymer sheet quality.

Starch-based edible polymer exhibits physical characteristics similar to plastic polymer in which they were odorless, tasteless, and colorless. The ability of polysaccharide-based (starch, carrageenan and chitosan) coating has used to extend the shelf life of strawberry fruit mainly for industrial application (C. Ribeiro *et al.*, 2007).

Gelatin was unique in forming a thermo reversible substance with a melting point close to body temperature, which was mainly significant in edible and pharmaceutical applications. At approximately 40°C, gelatin aqueous solutions were in the sol state and form physical, thermos reversible gels on cooling. Gelatin was encapsulated low moisture or oil phase food constituents and pharmaceuticals (T. Bourtoom, 2008). Addition gelatin was competent to strong clear and strong films and was used for microencapsulation and capsule coatings in food and pharmaceutical manufacturing.

Zein, a prolamin protein and therefore dissolves in 70-80% ethanol and relatively hydrophobic and thermoplastic material. This Zein coating has also shown an ability to reduce moisture and loss of firmness and delay color alteration in fresh fruit like apples. Now used as a crust for candy, nuts, fruit, pills, and other encapsulated foods and drugs (Dhanya H and Divia S., 2012).

This research work details with incorporating the potato starch to make biodegradable packaging film using glycerol as a plasticizer. Starch is a very well known carbohydrate polymer, and plants from it is obtained grow in nearly all the temperate zones. Optimization of preparation condition would help us to study the feasibility and potential of this starch with other additives to obtain a biodegradable as well as high tensile strength plastic. The films were prepared by casting technique using a film forming solution.

Lipid compounds exploited as edible polymer consist of acetylated monoglycerides, natural wax, and surfactants. The most operative liquid substance were paraffin wax and beeswax. In contrast, the hydrophobic characteristic of lipid forms thicker and more brittle films. Accordingly, they must be associated with film forming agents such as proteins or cellulose derivatives. Generally, water vapor permeability decreases when the concentration of hydrophobicity phase rises (F. F. Shih *et al.*, 2019).

Mineral oil consists of a liquid paraffin and naphthenic hydrocarbon. Various types of wax were used as barrier films to gas and moisture (skin on fresh fruits) and to improve the surface appearance of various foods (e.g., the sheen on sweet) (F.F. Shih *et al.*, 2011). If applied as a thick layer, they must be removed before consumption (certain cheese); when used in thin layers, they were considered edible. Various types of wax (notably paraffin, carnauba, candellila and bees wax were the most efficient edible compounds providing a humidity barrier.

Instead of antibiotic treatment, a new approach is needed to prevent the proliferation of microorganisms, also to protect food from oxidation, Plant extracts as natural additives in foods, in this study rosemary (*Rosmarinus officinalis* L.) oil has been applied instead of mineral oil as plasticizer in polymerization process. Due of its antioxidant properties, antimicrobial activity against food borne pathogens including *Listeria monocytogenes*, this oil blend can be optimized. Thus packing material developed from this study could also be used for frozen storage packing with further optimization studies. Thermogravymetric Analysis (TGA) is especially useful for the study of polymeric materials, including thermoplastics, thermosets, elastomers, composites, films, fibers, coatings and paints. Olive oil was used to prepare films with better barrier properties and plasticized films for packaging. Olive oil, as a lipid, can

be beneficial to improve the barrier properties of hydrocolloid edible films. Edible films were prepared from zein and zein-whey protein composite using glycerol and olive oil as plasticizers. Films prepared olive oil showed higher glass transition temperatures which provide better barrier properties. This study focused on preparing edible beta glucan sheet with rosemary oil blends and its antimicrobial studies are carried out with selected foodborne pathogens and further characterization studies performed using GC MS for polymer blends and Thermogravimetric analysis for polymer sheet.

Materials and Methods

Collection of Sample

Food borne isolates obtained from microbiological laboratory, Ambattur respectively bacterial strains *E. coli*, *Salmonella typhimurium*, *Vibrio cholerae* and fungal strains *Candida albicans*, also standard *Aspergillus brasiliensis* ICIM 1196 strain collected from same laboratory for the present study. All the bacterial and fungal cultures were subcultured and maintained in lab.

Preparation of Yeast Culture

About 0.1mg of *Saccharomyces cerevisiae* yeast powder was inoculated with sterile 100ml of SDA broth in conical flasks and incubated at 150 rpm, 30°C for 48 hrs. Then followed by repeated sub culturing of yeast culture was carried out.

Extraction and Optimization of Beta-Glucan

The yeast culture biomass was obtained through centrifugation at 5000 rpm for 10 min, and the pellet mass was washed with distilled water twice and then dried at 40°C for two days. Followed by β -glucan was extracted by adding 200ml of 1% sodium hydroxide to 4g of yeast biomass and then centrifuged in order to get rid of the supernatant. The precipitate was suspended in sodium hydroxide and the pH was adjusted to 7 (Al-Jumaiee *et al.*, 2019). Next, 30 ml of 0.5 N of HCl was added and left for an hour after centrifugation was carried out at 5000 rpm for 20 min; the precipitate was washed with distilled water. Then 20ml of ethanol was added and left for 12hrs. Finally, the mixture was then centrifuged at 5000 rpm for 20 minutes and supernatant was collected and stored at 4°C until further usage.

Optimization

Autolysis and hot water treatment were performed according to the methods of (Liu *et al.*, 2008) with temperature modifications. About 30ml of cell suspension, pH 5.0, was added to 3% NaCl and incubated for 24 h at 55 °C in a water bath. Then, the culture was heated to 85 °C temperature for 15 min and cooled down to 25 °C, the mixture was then centrifuged at 4500g for 10 min and the above extraction was carried out. The supernatant was collected and stored at 4°C until further usage.

Preparation of Beta-Glucan Biopolymer Sheet

Polymer blend were mixed with 100ml distilled water and boiled for 5 minutes. Avoid lumps and bubbles in prepared blend from the top. Let the liquid cool it till it stops steaming pour the liquid onto a glass petriplates and quickly till it as thin layer. Let the polymer sheet dry for at least 24 hrs to 72 hrs when the polymer sheet is completely dry, it should peel off easily, carefully remove it from the glass petriplate and cut the polymer sheet into appropriately sized square. Mineral oil was used as control against Rosemary oil in biopolymer blend preparation.

The prepared sheets were kept under UV light for 10 min for sterilization procedure (Fig 1).

Antibacterial and Antifungal activities of Edible Films

The sterile edible film samples were cut in to discs with 6mm diameter using sterile punch. (Fig. 2)

Antibacterial activity of Edible Films

The antibacterial activity of β -glucan, rosemary oil, and antibiotic (Ciproflaxin) were studied against the bacterial strains *Salmonella typhimurium*, *Vibrio cholerae*, *Escherichia coli* respectively. Sterile swab was dipped into bacterial inoculum (*Salmonella typhimurium*, *Vibrio cholerae*, *Escherichia coli*) and swabbed on Muller-Hinton Agar (MHA) covering the entire agar surface. Allow 3-5 minutes for the surface of the agar to dry before placing the discs. The plates were incubated at 37°C for 24 hours. Then the antibacterial activity was determined by measuring the diameter of zone of inhibition (Y Sricandace *et al.*, 2018).

Antifungal activity of Edible Films

The antifungal activity of β -glucan, rosemary oil, and antibiotic (Amphotericin B) were studied against the fungal strains *Aspergillus brasiliensis* ICIM 1196 strain, *Candida albicans*. Sterile swab was dipped into fungal inoculum and swabbed on Sabouraud Dextrose Agar (SDA) covering the entire agar surface. Allow 3-5 minutes for the surface of the agar to dry before placing the discs. The plates were incubated at for 48 hours. Then the antifungal activity was determined by measuring the diameter of zone of inhibition (Y Sricandace *et al.*, 2018)

Gas Chromatography-Mass Spectrometer

Sample Preparation

Biopolymer sheet was dried in hot air oven for 30 min. After drying the sheet crushed into powder form, transferred in to eppendorf tube taken for GC-MS analysis.

Specifications: A Shimadzu GC-2010 Plus gas chromatograph was equipped with a straight deactivated 2mm direct injector liner and a 15m Alltech EC-5 column (250 μ I.D., 0.25 μ film thickness).

A split injection was used for sample introduction and split the ratio was set to 10: 1. The oven temperature program was programmed to start at 35°C, hold for 2 minutes, then ramp at 20°C per minute to 450°C and hold for 5 minutes.

The helium carrier gas was set to 2 ml/minute flow rate (constant flow mode).

Mass spectrum

Thermogravymetric Analysis

TGA measures the amount and rate (velocity) of change in the mass of a sample as a function of temperature or time in a controlled atmosphere. The measurements are used primarily to determine the thermal and/or oxidative stabilities of materials as well as their compositional properties. The technique can analyze materials that exhibit either mass loss or gain due to decomposition, oxidation or loss of volatiles (such as moisture). Approximately 10 mg of sample was heated at a rate of 20°C/min with the PerkinElmer TGA.

Results and Discussion

Foodborne Isolates

The obtained bacterial and fungal isolates were streaked on selective medium respectively as followed.

Beta-Glucan extracted from *Saccharomyces cerevisiae*

When compared to beta glucan extraction method followed by (Shayma Thyab *et al.*, 2022) optimized method shown higher yield of beta glucan in this study (Table.3)

Polymer sheet preparation

Beta-glucan and Rosemary oil blend biopolymer sheet preparation.

Gass Chromatography-Mass Spectrophotometry

GC MS analysis of Biopolymer-3 blend, 10.72 R.T denoted Camphene, 17.02 and 17.07 R.T denoted Galactose and D-Glucose, 13.78 R.T denoted camphor, 15.23 and 15.88 R.T denoted to Rhamnose, 19.65 and 22.02 R.T denoted Cellobiose.

Thermo gravymetric Analysis

The TGA results show that the edible beta glucan polymer undergoes thermal degradation beginning at 99°C and with a total mass loss of 99.0%. There is a small amount of inert residue remaining (8.38%).

As replacement to synthetic polymer material based packaging, Edible biopolymers are broad category of polymer emerging worldwide. Edible polymer can maintain the organoleptic properties of packaged foods, provided that contains various components like flavorings, coloring, and sweeteners (T. Bourtoom, 2008), also can be an alternative source for packaging due to their precise physicochemical properties and biodegradability. Biopolymers based food grade additives and their applications constantly increasing in food and medical industries.

Polysaccharides are an indispensable component of many foods. Digestible polysaccharides are a good source of

calories and glucose needed for normal metabolic process in the body. Moreover, a large amount of indigestible dietary fiber exerts beneficial health activities in the body (Ferretti. F *et al.*, 2017). One of the widely known and documented bioactive polysaccharides is Beta-glucan. β -glucan intake and associated health benefits such as reduction in glycemic index and serum cholesterol; control of diabetes, cardiovascular diseases, cancer, and hypertension; immune-enhancing properties; antimicrobial (antibacterial, antiviral) properties; and wound healing activities have been reported (De Souza Bonfim-Mendonca *et al.*, 2017).

The US Food and Drug Administration recommended regular ingestion of 3g of β -glucan from cereal sources, such as oats or barley, along with a low cholesterol diet, for reducing the risk of heart-related diseases (e-CFR, 2019).

Gelatin was encapsulated low moisture or oil phase food constituents and pharmaceuticals (T. Bourtoom, 2008). Addition gelatin was competent to strong clear and strong films and was used for microencapsulation and capsule coatings in food and pharmaceutical manufacturing. Lipid compounds exploited as edible polymer consist of acetylated monoglycerides, natural wax, and surfactants.

The most operative liquid substance used were paraffin wax and beeswax. In contrast, the hydrophobic characteristic of lipid forms thicker and more brittle films. Accordingly, they must be associated with film forming agents such as proteins or cellulose derivatives. Generally, water vapor permeability decreases when the concentration of hydrophobicity phase rises.

Efforts should also be made to reduce or eliminate the applications of chemically synthesized additives for food storage. Instead of antibiotic treatment, a new approach is needed to prevent the proliferation of microorganisms, also to protect food from oxidation, Plant extracts as natural additives in foods, in this study rosemary (*Rosmarinus officinalis* L.) oil has been applied instead of mineral oil as plasticizer in polymerization process. Due of its antioxidant properties, antimicrobial activity against food borne pathogens including *Listeria monocytogenes*, this oil blend can be optimized. Thus packing material developed from this study could also be used for frozen storage packing with further optimization studies.

Edible Tea bag Production

Blend (100 ml potable water+ 10 table spoon tea powder+ 20g sugar)
↓
Boiled in a medium saucepan for 4 minutes
↓
Filtered the solution
↓
About 5 ml of solution to each edible polymer packets and seal with pressed seal method
↓
Edible Tea bags (with boiling water -Instant tea can be made)

Fig.1 Biopolymer sheet preparation

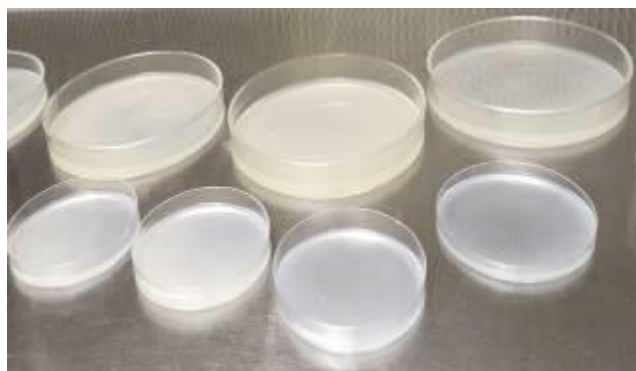


Fig.2 Biopolymer edible Disc



Fig.3 *Salmonella* on Xylose-Lysine-Deoxycholate (XLD) agar



Fig.4 *Vibrio cholerae* on Thiosulfate-Citrate-Bile-Salt Sucrose (TCBS) agar



Fig.5 *Escherichia coli* on Eosin-methylene blue (EMB) agar



Fig.6 *Candida albicans* on Sabouraud Dextrose Agar (SDA)



Fig.7 *Aspergillus Brasiliensis* on Sabouraud Dextrose Agar (SDA)



Fig.8 Beta-glucan extraction

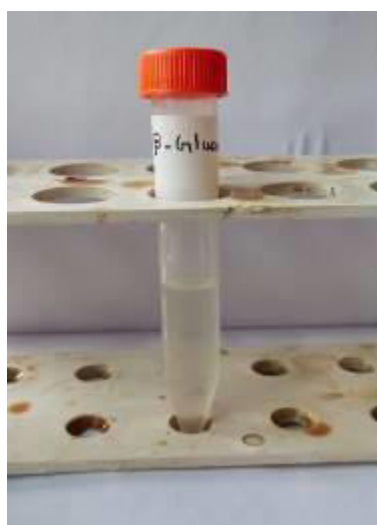


Fig.9 Beta-glucan Optimization

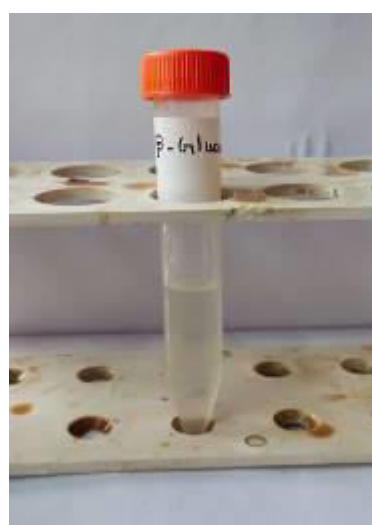


Fig.10 Beta-glucan

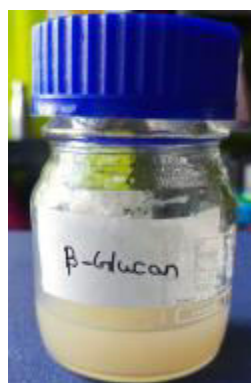


Fig.11 Rosemary oil



Biopolymer Sheet



Fig.12 Biopolymer sheet

Antimicrobial activities of Biopolymer sheet:

Antibacterial activity of Biopolymer sheet:

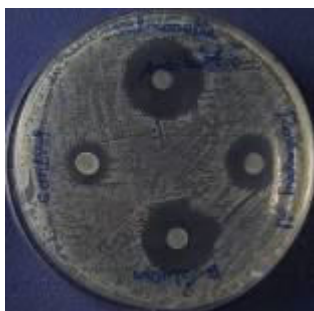


Fig.13 *Salmonella typhimurium*



Fig.14 *Vibrio cholera*



Fig.15 *Escherichia coli*

Antifungal activity of Biopolymer sheet:



Fig.16 *Aspergillus brasiliensis* ICIM 1196

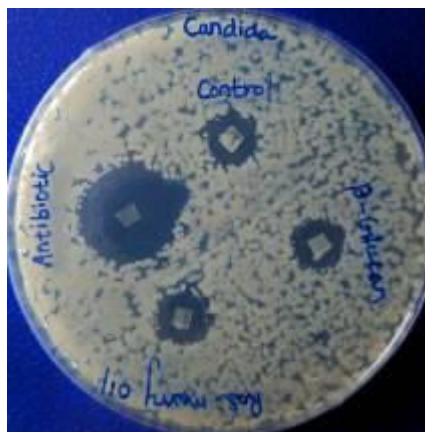


Fig.17 *Candida albicans*

Fig.18 Biopolymer Sheet 3 blend-GC MS Analysis

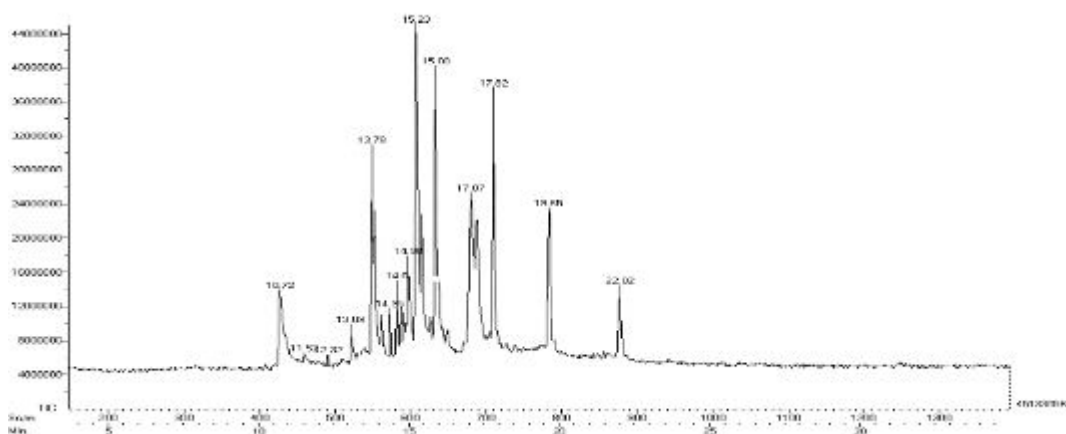
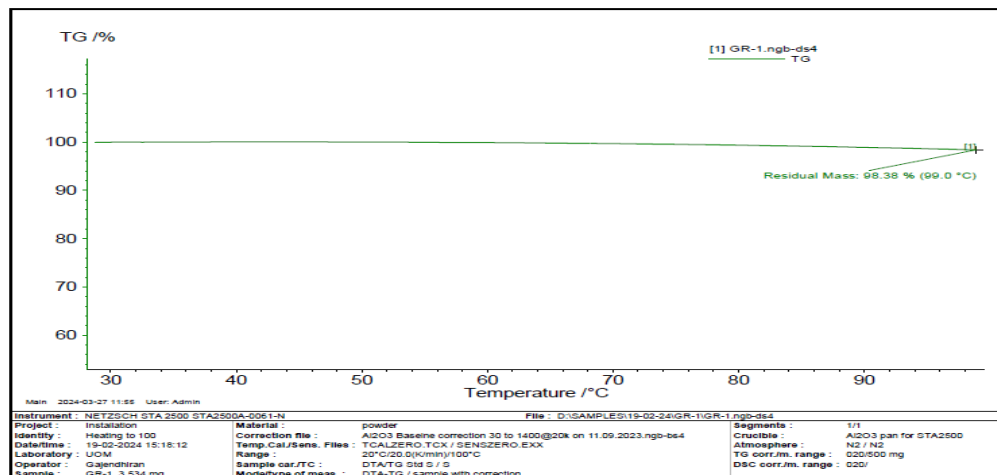


Fig.19 Thermo gravymetric Analysis of Biopolymer Sheet 3



Edible Tea Bag Production



Fig.20 Edible Tea Bag



Fig.22 Edible Tea Bag with Polymer Sheet 1



Fig.23 Edible Tea Bag with Polymer Sheet 2



Fig.21



Fig.24 Edible Tea Bag with Polymer Sheet 3

Table.1 Biopolymer blend composition

Ingredients	Gms/Liter
Distilled water	100ml
Potato starch	2g
Gelatin	2g
Vegetable glycerin	1ml
Rosemary oil	0.5ml
Beta-Glucan	5 mg

Microscopic Appearance of Food Borne pathogens:

Table.2 Microscopic Appearance under light Microscope

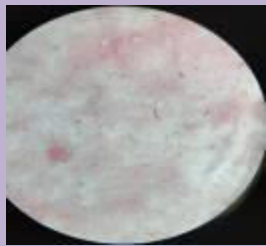
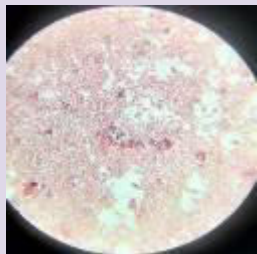
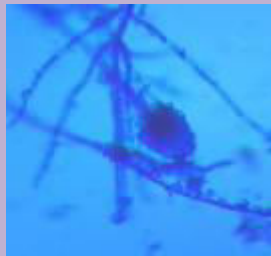
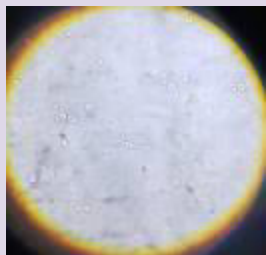
<i>Salmonella typhi</i> - Gram negative rod were observed	
<i>Vibrio cholerae</i> – Gram negative comma were observed	
<i>Escherichia coli</i>-rod shaped were observed	
<i>Aspergillus brasiliensis</i>-conidiophore flask were observed	
<i>Candida albicans</i>-round to oval shaped were observed	

Table.3 Optimal yield increase

Beta-glucan	Supernatant collected (in ml)	Dry Weight (in mg)
sample 1	20	0.2
sample 2	20	0.45

Table.3 Composition of Beta Glucan and Rosemary oil blends of Biopolymer Sheet

Biopolymer	Beta-glucan	Rosemary Oil
Sheet- 1	10mg	0.3%
Sheet-2	20mg	0.4%
Sheet-3	30mg	0.5%

Table.4 Biopolymer sheet preparation – 1

S. No	Name of the component	Melting	Molding
1	Beta-glucan	37°C -57°C	65°C
2	Rosemary Oil	40°C -55°C	65°C

Table.5 Biopolymer sheet preparation -2

S. No	Name of the component	Melting	Molding
1	Beta-glucan	37°C -57°C	70°C
2	Rosemary oil	40°C-57°C	70°C

Table.6 Biopolymer sheet preparation -3

S. No	Name of the component	Melting	Molding
1	Beta-glucan	37°C-57°C	80°C
2	Rosemary oil	40°C-57°C	80°C

Table.7 Antibacterial activity of Biopolymer sheet

Bacterial strain	Control	Beta-Glucan	Rosemary Oil	Antibiotic
<i>Salmonella typhimurium</i>	12mm	17mm	22mm	25mm
<i>Vibrio cholerae</i>	16mm	23mm	19mm	24mm
<i>Escherichia coli</i>	23mm	25mm	28mm	29mm

Table.8 Antifungal activity of Biopolymer sheet

Fungal strain	Control	Beta-glucan	Rosemary Oil	Antibiotic
<i>Aspergillus brasiliensis</i> ICIM 1196	19mm	21mm	22mm	28mm
<i>Candida albicans</i>	18mm	16mm	21mm	29mm

Beta glucan with optimization was estimated with 0.450mg/20 ml when compared to without optimization, only extraction yield was estimated as 0.20mg/20ml. This showed optimization could improve the yield of beta glucan from *Saccharomyces cerevisiae*. Three different biopolymer sheet prepared, among all Biopolymer sheet 3 was prepared with 30 mg Beta Glucan and 0.5% Rosemary Oil was found stable. For biopolymer sheet, blend melting and molding temperature was standardized based on beta glucan and rosemary oil boiling point, the mean temperature range was identified from 170°C to 176°C. Biopolymer sheet 3 prepared at molding 80 C showed best results TGA analysis. Also the polymer sheet texture, elasticity and durability were more suitable.

From this study, Both beta-glucan and Rosemary oil showed antibacterial activity as followed, for *Salmonella typhimurium* as 17mm and 22 mm, for *Vibrio cholera* as 23mm and 19 mm, for *E. coli* as 25mm and 28 mm respectively. The results were similar to ciprofloxacin antibiotic maximum found for *E. coli* as 29 mm. Both beta-glucan and Rosmary oil showed antifungal activity as followed, for *Aspergillus brasiliensis* ICIM 1196 as 21mm and 22 mm, for *Candida albicans* as 16mm and 21 mm respectively. The results were similar to Amphotericin B antibiotic maximum found for *Candida albicans* as 29 mm.

Likewise Alvarez *et al.*, 2014 reported on 15.7 mg/mL oregano was effective against *E. coli*, *S. aureus*, and *L. monocytogenes*, current study required higher EOs concentration. This might be due to the carvacrol as the main compounds of oregano bind well lemon peel. Other results from Aldana *et al.*, 2015 showed that 23 different

citrus EOs were more effective against *S. aureus*, *L. monocytogenes*, and *Salmonella enterica* as gram positive and gram bacteria, respectively. Daniela Sanchez Aldana *et al.*, 2015 reported that Edible films antimicrobial activity against food borne pathogenic bacteria viz., *Escherichia coli* O157: H7, *Salmonella Typhimurium*, *Bacillus cereus*, *Staphylococcus aureus* and *Listeria monocytogenes* by the disc diffusion method, with zones of inhibition measured after 24 h of incubation. The higher incubation zone was against *E. coli* (20.6 ± 1.17mm). Similar studies reported by the same for Edible films prepared with bagasse pectic extract Mexican lime essential oil inhibited the growth of food borne pathogenic bacteria and can be useful in the preservation of food to increase shelf life.

GC MS analysis of Biopolymer-3 blend, 10.72 R.T denoted Camphene, 17.02 and 17.07 R.T denoted Galactose and D-Glucose, 13.78 R.T denoted camphor, 15.23 and 15.88 R.T denoted to Rhamnose, 19.65 and 22.02 R.T denoted Cellobiose. Based on Swapna Nayaka *et al.*, 2020, results showed for GC-MS analysis of biopolymer sheet 3 had significant proportions of both beta glucan and rosemary oil fractions retained in blends were confirmed.

Thermogravymetric Analysis (TGA) is especially useful for the study of polymeric materials, including thermoplastics, thermosets, elastomers, composites, films, fibers, coatings and paints. Based on Ng *et al.*, 2018 previous study, the findings from this study identified as followed. The TGA results showed that the edible beta glucan polymer undergoes thermal degradation beginning at 99°C and with a total mass loss of 99.0%. There is a small amount of inert residue

remaining (8.38%). Thus biopolymer sheet 3 will be more suitable for instant tea bag production.

Author Contributions

Salma Sameera R: Methodology, Writing original draft.
Vidyadharani G: Concept, Preparation, Writing - Review & Editing.

Data Availability

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethical Approval Not applicable.

Consent to Participate Not applicable.

Consent to Publish Not applicable.

Conflict of Interest The authors declare no competing interests.

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