DISSERTATION
ON

"STUDIES ON PRODUCTION OF BIODEGRADABLE PLASTICS FROM PLANT PARTS AND ITS APPLICATIONS"

SUBMITTED TO THE
DEPARTMENT OF BIOTECHNOLOGY
SR INSTITUTE OF MANAGEMENT AND TECHNOLOGY,
LUCKNOW.

IN PARTIAL FULFILMENT
FOR THE
DEGREE IN BACHELOR OF TECHNOLOGY
IN BIOTECHNOLOGY

BY
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B. Tech Biotechnology (VIII Semester)
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UNDER THE SUPERVISION OF

DR. AMREEN KHAN
ASSISTANT PROFESSOR

SR INSTITUTE OF MANAGEMENT AND TECHNOLOGY,
LUCKNOW.

DECLARATION

I, **Devansh Gupta**, a student of **B. Tech Biotechnology (IV Year/ VIII semester)**, SR Institute of Management and Technology, Lucknow have completed my six months dissertation work entitled **"Studies on production of biodegradable plastics from plant parts and its applications**" successfully from the '***In- House***' under the guidance of Dr. Amreen khan.

I, hereby, affirm that the work has been done by me in all aspects. I have sincerely prepared this project report and the results reported in this study are genuine and authentic.

Devansh Gupta
Department of Biotechnology

CERTIFICATE BY INTERNAL ADVISOR

This is to certify that Devansh Gupta, a student of **B. Tech Biotechnology** (IV year/ VIII semester), SR Institute of Management and Technology, Lucknow has completed his six months dissertation work entitled "**Studies on production of biodegradable plastics from plant parts and its applications"** successfully. He has accomplished this piece of work '***In- House***' under my supervision. The dissertation was a mandatory part of his B.Tech. Biotechnology degree curriculum.

I wish him best of luck for his bright future.

Dr. Amreen khan
Assistant Professor
Department of Biotechnology
Faculty of Engineering

TO WHOM IT MAY CONCERN

This is to certify that Devansh Gupta**,** a student of **B. Tech Biotechnology** (IV year/VIII semester), SR Institute of Management & Technology, Lucknow, has completed his six months dissertation work entitled **"Studies on production of Biodegradable plastic from plant parts and its applications"** successfully. He has accomplished this piece of work '***In- House***' under the guidance of **Dr. Amreen khan**. The dissertation was a mandatory part of his B.Tech. Biotechnology degree curriculum.

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Er. Pankaj Gupta
Head of Department
Department of Biotechnology
Faculty of Engineering

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First, I would like to thank almighty God and my family for helping me starting from the beginning to the end of the project period.

I extend my supreme gratitude to **SR Institute of Management and Technology** for providing such kind of opportunity for students to broaden their perception on how the real world in the field of biotechnology looks like as well as or conducting the whole experiments and its effort to make sure to achieve its desired goals.

It gives me immense pleasure and unbound exultation to express my gratefulness to Hon'ble **Chairman Mr. Pawan Singh Chauhan**, **Dr. D.P. Singh (Director)** and all board members for giving me this opportunity with this organization. I pen down my deeply respect to the Head of the Department **Mr. Pankaj Gupta** and Deputy Head of the Department **Mohd. Ahmad** for their valuable support and guidance.

With great respect I convey my deep indebtedness to the Department of Biotechnology for their encouragement, guidance, and support throughout the project, they enabled me to develop an understanding of new concepts and testing. Especially thanks to Prof (Dr) Sanjay Mishra, Dr. Akanksha Sharma, Dr. Manish Srivastava, Mrs. Surabhi Kanaujiya. They all created a very good learning environment. I will always remember their cooperation and support. Thank you to all those whose names couldn't show up yet who helped me during my project.

Last but not the least, I feel privileged to offer my sincere thanks, and deep sense of gratitude to my project guide **Dr. Amreen Khan** for expressing her confidence in me, guiding me in implementing the project and providing the support, persistent, personal interest in the activities of the project from her inspection.

Devansh Gupta

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LIST OF ABBREVIATIONS

➢	FTIR	Fourier Transform Infrared Spectroscopy
➢	NMR	Nuclear Magnetic Resonance
➢	LD	Low Density
➢	HD	High density
➢	PSP	Potato Starch-based Plastic
➢	DSC	Differential Scanning Calorimetry
➢	TGA	Thermo gravimetric Analysis
➢	MR	Moisture Retention
➢	CRT	Chemical Resistance Test
➢	WRT	Water Resistance Test
➢	HRT	Heat Resistance Test

ABSTRACT

This research explores the potential of utilizing a waste, specifically orange peels, and banana peels, as feedstock to produce biodegradable plastics. The study involves a comprehensive investigation into the extraction and conversion processes, aiming to develop a sustainable and eco-friendly alternative to traditional petroleum-based plastics. Orange peels and banana peels are chosen for their abundant availability and rich composition of biopolymers. The extraction process involves isolation and purification of the biopolymers, followed by polymerization to produce biodegradable plastics. Characterization techniques such as spectroscopy and microscopy are employed to assess the structural and mechanical properties of the obtained bioplastics. Additionally, the biodegradability of the produced plastics is evaluated under stimulated environmental conditions. The findings of this study contribute to the development of greener alternatives in the field of plastic production, addressing environmental concerns associated with conventional plastic waste. The research involves the extraction of biopolymers from these fruit peels, with a focus on optimizing the extraction process for maximum yield. The extracted biopolymers are then subjected to polymerization to obtain biodegradable plastics. The study also explores the physical and chemical properties of the resulting plastics using various analytical techniques, including spectroscopy and microscopy. Furthermore, the biodegradability of the plastics is assessed under stimulated environmental conditions to determine their potential as eco-friendly alternatives to traditional plastics.

CHAPTER – 1

1. INTRODUCTION

As of my last knowledge update in December 2023, there have been numerous studies on the production of biodegradable bioplastics and their applications. Bioplastics are a type of plastic derived from renewable resources, such as plants, and they are designed to be more environment friendly than traditional plastics derived from fossil fuels. The main advantages of biodegradable bioplastics includea reduced reliance on non-renewable resources, lower greenhouse gas emissions, and the potential for biodegradation.

SYNTHESIS OF BIO BASED MATERIAL FROM FRUIT WASTE OF ORANGE PEEL AND BANANA PEELS

Plastics contribute most to surface litter which is now a problem to even the leastdeveloped countries. Nowadays, the disposals of waste plastic packaging poses challenges in term of concomitant non-degradability. Methods normally used to destroy other types of waste such as burning and burying are not suitable for plastic destruction. The burn of plastic may release dangerous gases to the atmosphere. While burying plastics in soil, it cannot destroy plastics as they are not biodegradable. Meanwhile, the cost for the process of plastic elimination is very high and will affect the country economically. The incorporation of inorganic fillers into thermoplastics has been widely practiced in industry in orderto improve certain properties of the thermoplastics such as heat distortion temperature, hardness, toughness, dimension stability, stiffness, mold shrinkage, and also cost reduction. Besides that, the incorporation of biodegradable materialsinto non-degradable polymers has become an interest for many years as alternativeto non-degradable polymers due to environmental pollution. Although there are many advantages to using synthetic polymers, the durability of the polymers allows them to accumulate in the environment after their useful life is completed.

The biodegradable polymers could be an alternative to the conventional plastic materials. These polymers being biodegradable can be disposed in safe and ecologically sound manner, through disposal processes like composting, soil application, and biological wastewater treatment. These waste plastic packaging could be profitably used in the manufacture of reinforced composites because they possess attractive physical and mechanical properties. They impart the composite high specific stiffness and strength, high carbon content, low density, high toughness, non-corrosive nature, good thermal properties, reduced tool wear, less abrasion to processing equipment, renewability, and biodegradability.

In recent years, the detrimental effects of conventional plastics on the environment have become increasingly evident. Their non-biodegradable nature leads to harmful pollution and poses a significant threat to ecosystems and human health. As a result, the development of alternative materials that are both effective and environmentally friendly has gained substantial attention.

One promising solution is the production of biodegradable plastics from plant parts. This area of study focuses on harnessing the renewable resources found in various plant materials to create sustainable and eco-friendly alternatives to traditional plastics. By utilizing plant-based polymers, these biodegradable plastics offer the potential to mitigate the environmental impact caused by their synthetic counter parts.

This research aims to explore the production processes involved in transforming plant parts into biodegradable plastics and investigate their diverse applications. By understanding the chemical and mechanical properties of these materials, we can gain insights into their feasibility for use in various industries, such as packaging, agriculture, and biomedical fields.

This study will delve into the synthesis methods employed to extract and modify polymers from plant sources, assess the performance and degradation characteristics of the resulting biodegradable plastics, and examine their potential applications in different contexts. Additionally, the environmental implications of adopting biodegradable plastics will be considered, including their compost ability and impact on waste management systems.

The findings of this research will contribute to the growing body of knowledge surrounding the production of biodegradable plastics from plant parts. By exploring their applications across various sectors, we can pave the way for moresustainable practices and contribute to a healthier planet.

Plastics are incredibly important in modern life. In terms of consumption, their yearly production is probably going to surpass 500 million tons by 2020. Plastics have established their value in emerging technology and medicinal developments. However, the majority of these plastics are currently released by the Indian government. It is still a major issue, and their consumption poses a serious harm to the ecosystem, the flora, and the animals. The accumulation of these dangerous chemicals in wildlife and humans is a major worry due to the chemical leakage from plastic items. According to one assessment, there are an estimated 5 trillion plastic pieces floating about in oceans from the Antarctic to the Artic of various nations. Potential green alternatives are urgently needed because of the environmental damage caused by plastics. Except when used as compost, food waste is intended to be an undesirable substance. Shrimp peels, orange peels and old coffee grounds are among the many food-derived wastes that are being transformed into bio plastic on a large scale. Arête Marko Polo and colleagues recently focused on integrating local food waste from urban environments and diverted fruit waste, which usually ends up in the land fill. Because main food waste sources like Spanish orange peels and Barcelona seafood have been successfully transformed into recyclable bio plastic. The material is typically gathered and sorted in food waste facilities, where bio plastic is produced.

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1.1 BIOPLASTICS

Bio plastics are defined as "plastic based on renewable resources or plastics that are biodegradable and compostable" by the European Bioplastics Organization (EBO). These bioplastics decompose naturally or when stimulated, primarily through the enzymatic activity of microorganisms, into CO2, H2O, organic compounds, or biomass. The following four requirements must be met to qualify as a bioplastic polymer:

1.1.1 Chemical characteristics:

Organic matter must comprise at least 50% of the end composition.

1.1.2 Biodegradation:

Under conditions promoting composting, the developed polymer should degrade by at least 90% of its weight or volume in six months.

1.1.3 Disintegration:

Under controlled composting conditions, the bio-based polymer should, at the very least, fragment microscopic, undetectable components (2mm) within two months.

1.1.4 Eco toxicity:

After biodegradation for six months, non-degradable biopolymer residues should not pose a danger to plant growth. The biodegradable plastics are made of either natural or fossil sources and are biodegradable or mineralizable into water and carbon dioxide by the action of microorganisms, in a reasonable period of time. The term "Biodegradability" is defined as the characteristics of the material that can be microbiologically degraded to the final products of carbon dioxide and water, and therefore is unlikely to persist in the environment. Each material utilised, the properties of the bioplastic produced, and varied product configurations may all affect the bioplastic's production process differently. Each process is intricate and uses a multitude of techniques, components, and compositions depending on the material being processed. Pre-Treatment including processes such as grinding, drying, hydrolysing the material. Not all parts of the waste are used in the bioplastic manufacturing process, such as extracting only its starch and cellulose. And the most important part is characterizing materials such as adding plasticizer agent, odour controlling agent, and biological material.

1.2 POTENTIAL OF FOOD WASTE AS BIOPLASTIC MATERIAL

1.2.1 Sludge waste from food industry

The sludge that is freshly activated from wastewater treatment in a food processing industry can be used to make biodegradable plastic. Active sludge contains various types of microorganisms that can be used to produce PHB (Poly-b-hydroxybutyrate), produced by various bacteria as microbial polyester and stored in cells in the form of granules This material can be suitable for the synthesis of environmentally friendly plastics material. PHB production costs are very high, so the use of activated sludge is expected to be more efficient.

1.2.2 Cassava peel

Because of its starch content, cassava peel is an agricultural waste that can be used as a bio plastic material. Starch is universal, renewable, and easily obtained so that it becomes potential material for bio plastic manufacturing. The study of making bioplastics from cassava peel starch has been carried out by combining the materials of starch and chitosan as a plasticizer by using sorbitol. The results showed that the best mechanical properties for bioplastics with a tensile strength value of 1.37 MPa was obtained at the addition of sorbitol 30% with a ratio of starch: chitosan.

1.2.3 Banana peel

Banana peels as agricultural processing waste can be used in making bioplastics because they contain cellulose, starch, pectin, and other polymers. Cellulose is modified to obtain thermoplastic materials through acetylation (cellulose 9 acetate). The use of pectin in making bioplastics functions as an emulsifier that increases intermolecular bonds in the film.

1.2.4 Jackfruit seed

Jackfruit seed, which constitutes 8-15% of the jackfruit, is potential food wastes due to its high starch content. It can be used for bioplastics production as raw material. A study on making bioplastics from jackfruit seed starch has been carried out.

1.2.5 Durian seed

Durian seeds are waste from food processing as well as part of durian fruit that is not consumed because it feels slimy and itchy on the tongue. Even so, the seeds have nutrients including protein, carbohydrates, fats, calcium, and phosphorus. Carbohydrates in the form of starch in durian seeds have the potential to be used as material for making bioplastics. However, starch-based bioplastics have some disadvantages such as low mechanical strength and less resistance to water.

1.2.6 Pomegranate peel

Has rich source of bioactive compounds. It consists of lignin-5.7% and hemicelluloses-10.8%, cellulose-26.2% and pectin-27%. On acid hydrolysis, the polysaccharides present in peel are converted into monosaccharide’s which can break down into cellulose, hemicelluloses, and lignin components. These components further are used to develop bio plastic.

1.2.7 Orange peel

The peel contains carbohydrates which can be used for the production of biomolecules. Careless discharge of unprocessed peels causes many environmental problems. Therefore, it is recommended to collect the waste and convert it into bioplastics.

1.3 DIFFERENT KINDS OF PLASTILIZER USED IN PRODUCTION OF BIOPLASTIC

Plasticizers are organic molecules, that are added to polymers, to reduce brittleness, reduce crystallinity; improve durability, toughness; lowering melting temperatures. These reduce polymer-polymer contact hence the rigidity. of the 3D structures is also reduced, allowing deformation without rupture. In the production of bioplastic, different kind of plasticizers are used that includes polyols such as glycol, glycerol, sorbitol, fructose, sucrose, and mannose, fatty acids such as palmitate or myristate. Out of these, glycerol is most widely studied and used plasticizer because of its non-toxicity, low cost, and high boiling point (292°C) properties.

1.4 ADVANTAGES

1.4.1 Benefits of using biodegradable bioplastics for waste management

To limit the quantity of plastic trash produced by society, grocery store chains, the food service business and the agricultural sector have successfully implemented bioplastic packaging. Managing biological waste is made simpler by biodegradable plastics.

1.4.2 Bioplastics' carbon neutrality

Since global warming has become a significant worry, bioplastics have gained more attention as a way to reduce society's overall carbon dioxide (CO2) emissions. Whereas making regular plastics necessitates the net addition of carbon to the atmosphere, the CO2 released by BPs originates from biomass. It may therefore be carbon neutral throughout its existence. Even if the BPs feedstock may be carbon neutral, bioplastics processing may still be powered by fossil fuel.

1.4.3 Possibility of a much smaller carbon footprint

It should be noted that whether a bioplastic permanently stores the carbon drawn from the air by the growing plant significantly impacts its carbon footprint. A synthetic material derived from living organisms sequesters the CO2 the plant takes during photosynthesis. This sequestration is undone if the resulting bioplastic reverts to CO2 and water. However, a permanent bioplastic that resembles polyethylene or other common plastics can permanently store CO2. The CO2 initially removed from the atmosphere is still trapped in the plastic, even after it has been recycled numerous times.

1.4.4 Reduction in energy use (Less Petroleum Dependence)

Possible petroleum shortages are now a significant worry. Compared to the production of conventional plastics, the production of bioplastics uses less fossil 13 fuel. Multilayer films made of polylactic acid had a life cycle assessment revealed their environmental impact was almost half that of films made of petroleum.

1.4.5 Manufacturing will pay less for energy

Nevertheless, just 4% of the oil consumed worldwide yearly is used to make plastics. Plastic production is more vulnerable to price fluctuations due to the lack of oil.

1.4.6 Avoid using limited crude oil

In comparison, producing one kilogram of plastic often takes more energy than producing one kilogram of steel or 20 kilowatt hours. About all of this is derived from fossil sources.

1.4.7 Reduction of CO2 emissions

Between 0.8 and 3.2 tons less carbon dioxide is produced per ton of bioplastics than petroleum-based plastics Utilizing biodegradable bioplastics results in a decrease in litter and an increase in composability. The decrease in the persistent litter is the benefit of biodegradable bioplastics that is most understood.

1.4.8 Benefits for rural economy

As nations worldwide hunt for alternatives to oil to protect the environment and achieve energy security, the price of crops like maize has increased significantly. This is because a growing interest is in manufacturing biofuels and bioplastics worldwide.

1.5 DISADVANTAGES

1.5.1 High Production Cost

The cost of producing bioplastics is higher than that of traditional plastic. If the usage of bioplastics on a large industrial scale spread, it will likely result in cost savings. The cost of producing bioplastics is more than twice as high as that of ordinary plastics. Several studies have supported this assertion.

1.5.2 Bioplastics have weak mechanical properties

Packaging materials comprised of starch and cellulose-based plastics have low longterm stability, poor processability, brittleness, and inferior mechanical properties because of their hydrophilic nature. The limited mechanical strength of bioplastics frequently restricts their use. It uses other environmentally hazardous components such as carbon, glass, nano clay, fibre, and nanoparticles.

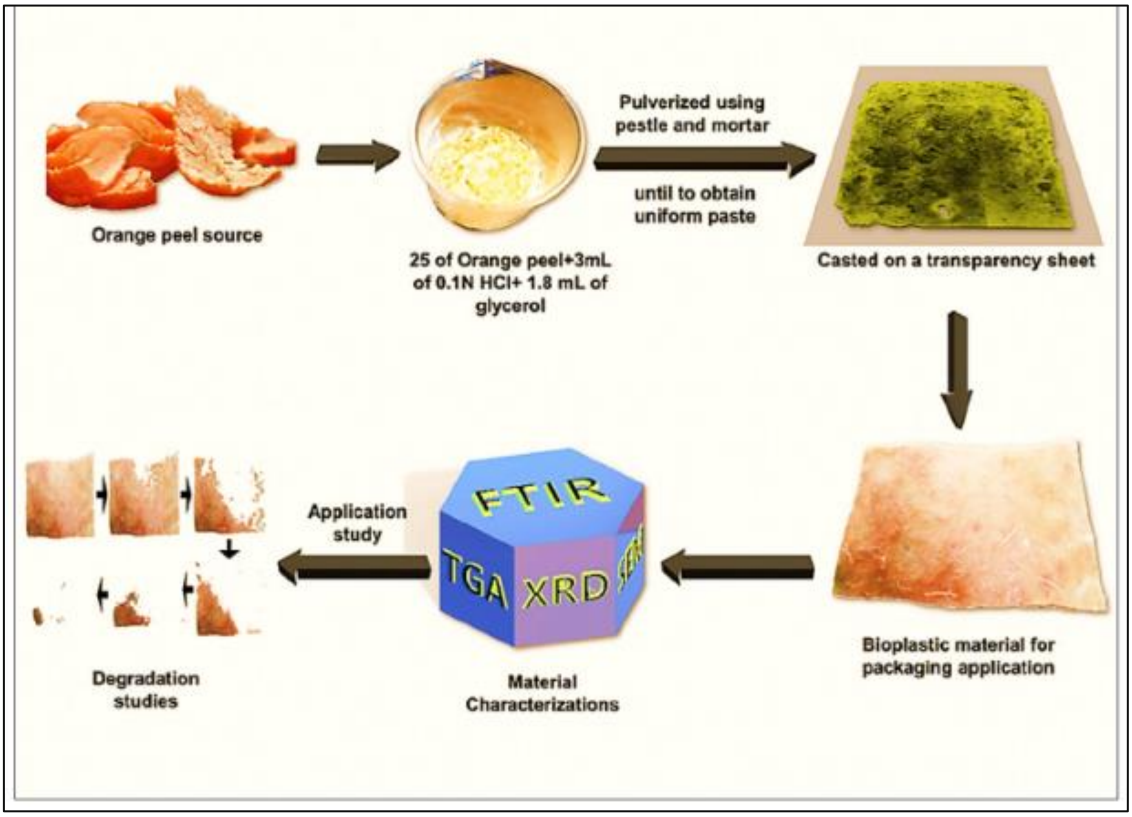

Fig No. 1: - Schematic representation of biobased material production

CHAPTER – 2

2. REVIEW AND LITERATURE:

2.1 Bio plastics made from kitchen waste:

According to the review paper of the "Bio plastics made from kitchen waste" by "Patil, Varsha Bhatt, Mitali Nagotkar, Disha Hebbar" in 2021.

Bioplastics are a good alternative to the regular petroleum-based plastics. These bioplastics can be made at home, on a small scale. The procedures are very simple,and the ingredients are readily available too. The bioplastics made here were fromkitchen wastes such as potato peels, orange peels, banana peels - potato starch- based plastic performed better in the tests. Bioplastic made from banana and orange peels turned out to be brittle. It was not elastic as we expected. They believe that some moderations in the procedure will lead to a more elasticity (Pratik Patil *et al., 2022*) Bioplastic from kitchen waste: An overview. International Research Journal of Engineering and Technology (IRJET).

2.2 Biodegradable Plastic Based on Orange peels for Packaging application:

According to the review paper of "Biodegradable Plastic Based on Orange peels for Packaging application" in 2019 that paper presents biodegradable plastic based on orange peel for packaging application. The objective of this research is to determine the optimum concentration of orange peel in producing biodegradable plastic and to evaluate the mechanical and physical properties of the biodegradableplastic based on orange peel for packaging application. The different percentagesof orange peel, which is 20%, 40%, 60% and 80% were prepared by mixed with the resin epoxy and hardener. The concentration of orange peel samples was exposed to the UV within 9 hours for drying process and finally coated with the superhydrophobic coating by spraying gun technique. The sample was tested by physical and mechanical tests include tensile strength, SEM microstructure analysis, water droplet test and biodegradable test. For the tensile strength was revealed that the higher average from concentration of 60% of orange peel with 52.26 MPa.

According to water droplet test, the concentration of 60% orange peel coated with super hydrophobic exhibit highest water contact angle upto 130°. While for the uncoated sample of 60% concentration showed contact angle of 90°. In term of degradation test, 20% concentration of orange peel exhibitsignificantly low degradation process because of the low loading concentration of orange peel. SEM illustrated that the interphase bonding between the orange peel and resin epoxy has a good bonding due to the concentration of 60% of orangepeel. Hence the concentration of 60% of orange peel can be one of the alternative raw materials that can be used for biodegradable plastic packaging application (Noraini Marsi1, Nur Athirah Huzaisham,1, Azrul Azlan Hamzah2, Atiqah Zafirah Zainudin1, Anika Zafiah Mohd Rus3, Abdul Mutalib Leman4, Rohani Rahmad1, Salwa. Mahmood1, Azrin Hani Abdul Rashid1, Dalila Mohd Harun1and Nofrizalidris Darlis1 (2019) Biodegradable Plastic based on orange peels for Packaging Application: An overview. Journal of Design for sustainable and Environment).

2.3 Biodegradable Plastic from orange peel:

According to the review paper of "Noraini Marsi" in the topic "Biodegradable Plastic based on orange peels for Packaging Application" This paper presents biodegradable plastic based on orange peel for packaging application. The objective of this research is to determine the optimum concentration of orange peel in producing biodegradable plastic and to evaluate the mechanical and physical properties of the biodegradable plastic based on orange peel for packaging application. The different percentages of orange peel, which is 20%, 40%, 60% and 80% were prepared by mixed with the resin epoxy and hardener. The concentration of orange peel samples was exposed to the UV within 9 hours for drying process and finally coated with the superhydrophobic coating by spraying gun technique. The sample was tested by physical and mechanical tests include tensile strength, SEM microstructure analysis, water droplet test and biodegradable test. For the tensile strength was revealed that the higher average from concentration of 60% of orange peel with 52.26 MPa. According to water droplet test, the concentration of 60% orange peel coated with superhydrophobic exhibit highest water contact angle up to 130°. While for the uncoated sample of 60% concentration showed contact angle of 90°. In term of degradation test, 20% concentration of orange peel exhibit significantly low degradation process because of the low loading concentration of orange peel. SEM illustrated that the interphase bonding between the orange peel and resin epoxy has a good bonding due to the concentration of 60%

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2.4 Biodegradable Banana Peels-Based Plastic:

According to the review paper of (Siti Noraiza *et al.,* 2022*)* in the topic "Biodegradable Banana Peels-Based Plastic" – This research purposely focused onsynthesis of bioplastic material by using banana peels. Achieve the main objective, the properties of bioplastic produced in terms of its strength, chemical compositions, and physical properties is being studied. Bioplastic was prepared by using banana peels as replacement to the conventional plastic material. Making bioplastic from banana peels as a substitute for traditional petroleum-based plasticis believed to be a successful key to enhance efficiency of the plastic industry. Glycerol is added as plasticizer which increases its flexibility. Inhibit growth of bacteria and fungi sodium metabisulphite is used. The degradation of bioplastic starts after three to four months from the date of manufacture. The atmospheric condition also affects the degradation period of bioplastic. The result showed thatthe plastic produced could bear the weight one and half times more than petroleumplastic. Bioplastic film can sustain the weight near about two kilograms, and which have enough tensile strength. The bioplastic prepared from banana peels that can be used as packaging material or as a carrying bag (Siti Noraiza Ab Razak*et al.,* 2022) "Biodegradable Banana Peels-Based Plastic-A review. Multidisciplinary Applied Research and Innovation).

2.5 B**anana peel starch to biodegradable alternative products for commercial plastics:**

According to the review paper of Arjun j, Manju R, Rajeswaran S R and Chandhru M "Banana peel starch to biodegradable alternative products for commercial plastics" Bioplastic products were produced successfully by mixing and casting method, several tests were conducted such as molding test and degradation test. In the molding test we can observe that the bioplastic can be molded into differentshapes, whereas in biodegradation test, a rapid degradation occurred in initial 6 days, the weight was reduced from 72.05 g to 44.70 g, followed by 100% decomposition can be expected in 60 days. Since the raw material used for the plastic is starch, it can be easily degraded by soil microorganisms and even thoughit did not reach all the properties commercial plastics further experiments can improve the quality of banana peel bioplastic and it can be used as the good alternative for commercial plastics and protect the environment (Arjun j *et al.*, 2023) Banana peel starch to biodegradable alternative products for commercial plastics. An overview of GSC Biological and pharmaceutical Science).

S. Veena and M. Rani successfully created bioplastic from banana peels and tested its biodegradation by microorganisms. The banana peel is boiled for 30 minutes, allowed to dry, and then blended into a homogenous paste with a mortar and pestle. To 25 grams of banana paste in a beaker, two millilitres of glycerol and 0.5 N HCl were added. The mixture was poured into a glass petri dish and cooked at 130°C until dry, then the plastic film was scraped off the top. After noting the biodegradability and rate of degradation of the created biopolymer, experiments with microorganisms are carried out. which comprises the method of serial dilution, Streak-plate technique and Technique for gram staining This process could result in significant amounts of bioplastic that are also biodegradable. In addition, the fabrication of bioplastics is made possible by microorganism biotechnology, which has great potential applications in a number of sectors, including agriculture, medicine, pharmaceuticals, veterinary care, and others.

Michael Ladenburg and J.P. Gustafsson synthesised bioplastic from apple pomace (AP) produced by Lyckens apple (Bredared, Sweden). Other materials in the study were orange pomance, glycerol and citric acid monohydrate The motorised apple crusher first processed fresh apples by grinding them into smaller bits. After that, the apple mush was put into a hydropress with a rubber membrane. The membrane forced the mash against the sieve walls after it had been filled with water, pressing the juice out. The residual product, the AP, was gathered and sent to the project's researchers, who kept it in storage at -20 °C until it was needed. Using a variable-speed rotor mill, the dry AP was ground to sizes of 1.0 mm and 0.2 mm to get this fine powder. A square form was filled with AP powder with a size of 1.0 mm or 0.2 mm, either washed or not, with glycerol 18 (GLY) in the range of 0–40% (w/w). A 10-tonne or 20-tonne manual compression n may be used, depending on the amount of force that would be exerted on the sample. It was done with a moulding press that was heated to 100 °C. Apple pulp is used to create a 3D bioplastic substance. similarly, Compression moulding can also be used to create 3D bioplastic materials from a mixture of orange and apple pomace The self-binding ability of biopolymer is noted. Bioplastic cups are made from apple pomace. Analysis of the mechanical properties of bioplastic materials from pomace is carried out. The tensile strength of both materials is noted. The effects of pressure, time for compression, particle size, and glycerol content on washed apple flavour are noted. Production of bioplastic films from apple pomace by casting is done. Highest values in terms of tensile strength and elongation at max for the compressed materials was reached with a mixture of washed apple pomace and glycerol. but similar properties are obtained using apple pomace alone. Orange waste can be added to the apple pomace to increase the tensile strength at the expense of the elongation at max.

For industrial purposes, Jayachandra S. Yaradoddi and his colleagues created biobased material from fruit waste, specifically orange peel. Orange peels from the Citrus sinensis variety were gathered and stored in the refrigerator at a temperature of around 15 °C until usage. An orange peel pestle and mortar were used for the pulverisation process, and they were heated to 120 C for 10 minutes in a hot air oven. 25 g of the material are combined well and uniformly with 3 ml of 0.1 N HCl and 1.8 ml of glycerol before being completely crushed with a pistol and mortar. The uniform paste was then poured into the moulds for the desired shape and part of the sample cast on the glass slab and room temperature for about 48 h. After the incubation time, the sample is peeled off from the glass slab/moulds. Different characterizations are done including biodegradation water and oil permeability test. FTIR, TGA, SEM, XRD is done to know about 19 functional group present and surface morphology. he FTIR spectra of orange peel were observed in the region of 450-4000 cm-1 Micro tensile analysis is also done. The bio-based material obtained is promising, although further characterization and improvements are necessary to achieve the desired features such as hydrophobicity.

Manasi Ghamande and coworkers synthesised DIY bioplastic from orange peels. This is created by combining four oranges and 25 grams of coffee grounds. All of the oranges' peels were first removed, and they were kept in the pot. After that, water is poured in and heated. The peels were then removed and ground after that. Then, a bowl containing 15 ml of water, 25g of tangerine peel, 25g of corn starch, 2g of sodium bicarbonate, 5 ml of lemon juice, 5 ml of sage oil, and 5 ml of vinegar is filled with the powder that has been created and heated. After heating, a bowl-like shape appears. and placed in a microwave for three to four minutes. At second time, we made the bioplastic bowl using orange peels and ground coffee both. Procedure for both is same the team performed a series of material experiments on the bioplastic to understand how and to what degree the material would transform when subjected to various strains and stresses. The DIY bioplastic project really helps in reducing the use of biodegradable and nonbiodegradable plastic. Also, there are only few limitations of this project, and we get the best benefits by using this bioplastic.

Nonni Soraya Sambudi and coworkers Modified Poly (lactic acid) with Orange Peel Powder as Biodegradable Composite PLA, Sweet orange (Citrus sinensis) Chloroform Hydrochloric acid , Sodium hydroxide , Deionized (DI) water are used for the experiment The chemicals are utilized without further purification or treatment Sweet orange (Citrus sinensis) peel collected , washed with and dried under the sun for 20 h, followed by drying in oven for 18 h at 60 ◦C . Dried orange 20 peel was then crushed using pestle and mortar, then milled into finepowder using electric blender. The powder was sieved and then stored in plastic container at room temperature until use. PLA pellets were dissolved in chloroform under constant stirring for 1 hr at room temperature to make 10 wt% PLA solution. Around 0.5 g orange peel powder was added into the PLA solution and stirred for another 1 hr. to prepare. The solution was casted onto flat glass plate and four petri dishes, respectively and dried for 24 h at room temperature The morphology of film was captured by using stereoscopic microscope. The sample functional groups were characterized using FTIR PLA sample of size 2 × 2 cm2 was placed and the intensity of transmitted light was computed in a wave range of4000–500 cm−1. Swelling and biodegradability tests were conducted. Mechanical properties and degradation rate is noted. It was proven that OPP has been incorporated into the PLA matrix by the presence of hydroxyl group in the high energy region, and C=C functional group at wavenumber

1608 cm^{-1}.Moreover, it was found that addition of OPP into PLA has generally decreased the tensile and modulus, but significant increase of elongation was observed at low loadings of OPP Syaubari, Abubakar, and coworkers synthesised and characterized biodegradable plastic from watermelon rind starch and chitosan by using glycerol as plasticizer Watermelon rind is a part of the watermelon that is rarely used, less application of polymer materials which has the potential to produce starch. Chitosan and lemongrass were chosen to combine with watermelon rind to increase its tensile strength. Glycerol was used as a plasticizing agent because it could be fully dissolved in starch solutions and other organic materials. For this case of study in watermelon, rind starch was produced by the extraction method, the yield makes up to 0.07%. Bioplastic films can be obtained by adding plasticizing agent and amylose/amylopectin, but this study is evaluating the differences between each 21 combinations of additives with different compositions. Therefore, conducted some analysis of Tensile Strength, FTIR, Scanning Electron Microscopy, and Biodegradation for this study. Sample starch +0.5 ml glycerol +0.75 g chitosan has the highest tensile strength value of 52 MPa, and the highest elongation value was found in the starch + glycerol 0.5 ml sample which was 14.2%. The effect of combined lemon grass oil influences the degradation process, resulting in a long time in the degradation process than other samples Watermelon rind is successful in producing starch to make biodegradable plastic with a yield value of 26%.

According to the Biodegradable Plastic based on Orange Peel for Packaging Application

Plastics contribute most to surface litter which is now a problem to even the least developed countries. Nowadays, the disposals of waste plastic packaging poses challenges in term of concomitant non-degradability. Methods normally used to destroy other types of waste such as burning and burying are not suitable for plastic destruction. The burn of plastic may release dangerous gases to the atmosphere. While burying plastics in soil, it cannot destroy plastics as they are not biodegradable. Meanwhile, the cost for the process of plastic elimination is very high and will affect the country economically. The incorporation of inorganic fillers into thermoplastics has been widely practiced in industry in order to improve certain properties of the thermoplastics such as heat distortion temperature, hardness, toughness, dimension stability, stiffness, mold shrinkage, and also cost reduction. Besides that, the incorporation of biodegradable materials into non-degradable polymers has become an interest for many years as alternative to non-degradable polymers due to environmental pollution. Although there are many advantages to using synthetic polymers, the durability of the polymers allows them to accumulate in the environment after their useful life is completed. The biodegradable polymers could be an alternative to the conventional plastic materials. These polymers being biodegradable can be disposed in safe and ecologically sound manner, through disposal processes like composting, soil application, and biological wastewater treatment. These waste plastic packaging could be profitably used in the manufacture of reinforced composites because they possess attractive physical and mechanical properties. They impart the composite high specific stiffness and strength, high carbon content, low density, high toughness, non-corrosive nature, good thermal properties, reduced tool wear, less abrasion to processing equipment, renewability, and biodegradability. Orange juice, both delicious and nutritious, is enjoyed by millions of people across the world every day. However, new research indicates that it could have potential far beyond the breakfast table. The chemicals in orange peel could be used as new building blocks in products ranging from plastics to paracetamol thus helping to break our reliance on crude oil. The orange peels have good thermal and chemical properties. When it contacts with any other material surface then some heat will be created due to friction. In that place, there is no need to supply any lubricant because orange peels act as self-lubricant because it contains some oil in its outer part.

CHAPTER – 3

3. MATERIAL AND METHODS:

3.1 MATERIALS

- Banana peels
- Orange peels

3.2 CHEMICALS

- Sodium hydroxide – it is used for neutralization.
- Plasticizers - Glycerol
- Acetone – used for washing purpose.
- Sodium bicarbonate – used for pH adjustment.
- Initiators or catalysts for polymerization (e.g., tin catalysts)

3.3 APPARATUS REQUIRED

- Beaker
- Glass Rod
- Weighing balance
- Grinder
- Standard measuring jar

3.4 INSTRUMENTS REQUIRED

3.4.1 FTIR SPECTROMETER

IR spectroscopy has been a workhorse technique for materials analysis in the laboratory for over 70 years. IR spectroscopy is a powerful method for the identification of functional groups. Because each different material is a unique combination of atoms, no two compounds produce the exact same IR-spectrum. The size of the peak in the spectrum is an indication of amounts of material present. The most important region of IR-spectrum is greater than 1650cm-1 whereas the fingerprint region of the spectrum cannot easily be used for identification of unknown compounds. 24The FTIR spectra of bio plastics film obtained from orange peels were recorded in SHIMADZU-8400 spectrometer using KBR pellet method. The FTIR spectrum of the sample was obtained at the wavelength in the range of 450- 4000 cm-

Table 1. Composition of Banana Peels

Items	**Content**
Cellulose	20-30%
Starch	15-20%
Pectin	10-15%
Lignin	<5%
Polyphenols	2-5%

Table 2. Composition of Orange peels

Items	**Content**
Cellulose	15-25%
Hemicellulose	20-30%
Pectin	20-30%
Lignin	<5%
Polyphenols	2-5%

3.5 METHODS:

3.5.1 Extraction of Raw Materials:

- Collected a significant quantity of banana peels and orange peels.
- Washed the peels thoroughly to remove dirtier and contaminants.
- Dried the peels in an oven then grind them into a powder.

Fig No. 2: - Pieces of Orange peels and banana peels

3.5.2 Solvent Extraction:

- Mixed the powdered peels with ethanol or methanol as a solvent.
- Performed solvent extraction to obtain a solution rich in sugar.
- Filtered the solution to separate liquid extract from solid residues.

Fig No. 3: - Boiled peels

3.5.3 Hydrolysis:

- Added sulphuric acid to the liquid extract to hydrolyze cellulose intosugars.
- Heated the mixture under controlled conditions.
- Neutralize the solution with sodium hydroxide to obtain a pH suitable forpolymerization.
- Filtered to remove any remaining solid residues.

3.5.4 Polymerization:

- Used the hydrolyzed solution as a feedstock for polymerization.
- Added lactic acid as a monomer and tin catalyst for initiation.
- Carried out the polymerization reaction under controlled conditions.
- Optionally, introduce plasticizers like glycerol for flexibility.

Fig No. 4: - Mixture of Orange peels and Banana peels

3.5.5 Film Formation:

- Depending on the polymerization method, form plastic films using castingor extrusion techniques.
- Allowed the films to dry and solidify.

Fig No. 5: - Dried Bio plastic by Hot Air oven

3.5.6 Characterization:

- Used Fourier Transform Infrared Spectroscopy (FTIR) to analyze chemical composition.

- Conducted Nuclear Magnetic Resonance (NMR) to confirm the structureof the polymer.
- Perform Differential Scanning Calorimetry (DSC) and ThermogravimetricAnalysis (TGA) for thermal properties.
- Assess mechanical properties (tensile strength, elongation at break) using appropriate testing methods.

3.5.7 Biodegradation:

The biodegradation of the plastic was carried out using the soil burial method, which involved taking two paper glasses and filling them with soil to the top. Pre weighed 0.5-grams chopped foils were placed at a specific depth on paper glass and reported as an initial weight prior to soiling conditions. To examine the impact of moisture content on sample degradation, one of the film samples was sprayed with water while the other was left dry. The weight drop of the sample is likewise seen after a week of observation with these two samples. Mechanical analysis and Universal Testing Machine (UTM).

3.5.7.1 Biodegradability:

Two 200 ml beakers and 1:1 gram of a pre weigh piece of bio plastic were taken in the beaker containing soil at depth of 5 cm from the surface. Some amount of water was sprinkled on the soil, so that bacterial enzymatic activities could be enriched. These sample were kept in the beaker for about 15 days and each 7 days of interval we observed the decrease in the weight of the bio-plastic material and results were recorded accordingly each experiment was done in triplicate in order to ensure results. The weight loss of the bio plastic was calculated using equation.

$$\text{Degradation \%} = \frac{\textbf{Final weight} - \textbf{Initial weight}}{\textbf{Initial weight}} \times 100$$

Initially the weight of the sample bioplastics is 1.03 gms. After a week of decomposition, the weight has been reduced by 0.4 gms. It weighed 0.9 gms Here by using the above-mentioned Formulae, the percentage of soil degradation for bioplastics is observed as 38.83%. In the degrading process a biodegradable plastic can be converted to carbon dioxide (CO2) and water and composting.

3.5.7.2 Biodegradation test:

It represents the results that were obtained from the experiment conducted for five weeks. The specimen that buried with the soil was then exposed to the UV light for five weeks. The degradation of plastic process occurred when there is any physical or chemical change in the polymer due to the environmental factors such as light, heat, moisture, chemical or biological activity. In term of degradation test for five weeks it is exhibit that 20% of orange peel significantly low degradation because of the low loading concentration of orange peel. The excellent degradation of the orange peel was from the concentration of 60% of orange peel. Based on the results, the higher the concentration of orange peel, the higher the process of degradation of polymer occurred. Based on previous research, bacteria and fungi are the microorganisms that involved in the degradation process. The different in soil conditions and the usage of a fibre caused the biodegradation of plastics proceeds actively based on their properties. This is due to the microorganisms responsible for the degradation differ from each other and have their own optimal growth conditions in the soil and also fibre act as a biodegradation additive and can provide higher oxygen permeability as it is consumed by microorganisms.

- Placed the produced biodegradable films in simulated environmental conditions.
- Monitored degradation over time, assessing microbial activity and structural changes.
- Analyzed the degradation products for environmental impact.

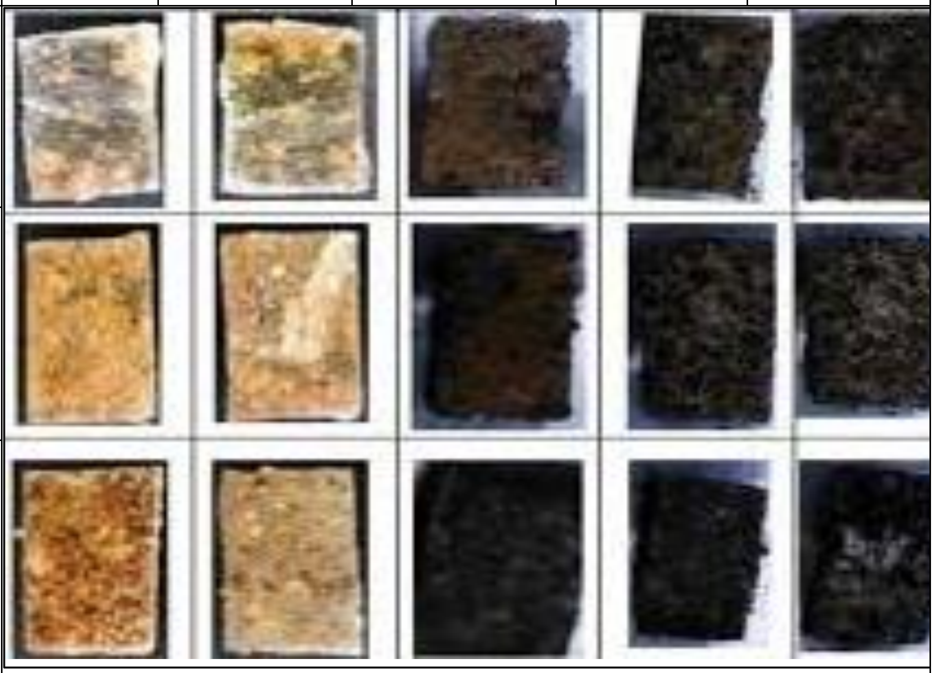
Concentration of orange peels	TIME				
	WEEK 1	WEEK 2	WEEK 3	WEEK 4	WEEK 5
20%					
40%					
60%					

Fig No. 6: - Degradation of biodegradable plastic with different concentration of orange peel

3.5.7.3 Water Absorption:

Water absorption is used to measure the amount of water that got absorbed under certain conditions and specifications. Table 3 shows the result of the water absorption test of bioplastic with different percentages of corn starch as a-biopolymer and various types of solvent. A sample with 1 % of corn starch has the highest water absorption water uptake which is 108.98 % while the lowest water adsorption was recorded at 60.65 % with 3 % of corn starch present in the bioplastics. As for different types of solvent used, highest water adsorption happens when water was used as a solvent at 43.48 % and the lowest is at 7.14 % for the sample of banana peels with chloroform as a solvent. From Table 3, it can be concluded that the amount of water adsorption of the bio plastic was related to its concentration of corn starch used. In addition, the percentage of water adsorption can also be affected by the types of solvent used. Bio plastic with the lowest water absorption will have longer shelf life.

3.5.7.4 Statistical Analysis:

- If applicable, perform statistical analysis on the results to determine significance.

3.5.7.5 Safety Precautions:

- Adhere to safety protocols when handling chemicals and equipment.

Note:

- Maintain detailed records of procedures, measurements, and observations.
- Replicate experiments to ensure reproducibility.
- Adjust methods based on specific goals and outcomes.
- Always consider safety guidelines, ethical standards, and adapt themethods to the specific capabilities of your laboratory.

CHAPTER – 4

4. RESULT AND DISCUSSION:

4.1 Biological Degradation:

The biodegradation test was conducted to understand sample degradation in the soil concerning time, since microbial activities. For the soil microbial activity, moisture content plays a crucial role in enhancing the sample's degradation Therefore, two separate tests considered understanding the mechanism of biodegradation of the sample. In one experiment, a sample with moisture content (sample A) and another test sample in the absence of extra moisture (sample B) kept for 1 week. Biodegradation of bio plastic can vary from weeks to mo0nths depending on the material used. Two samples are kept in well-ventilated area with sufficient sunlight. The sample A is watered 2-3 times a day i.e. It is kept moisture locked on the other hand sample is left dry. After a week it is noted that sample A is almost degraded while little change is observed in sample B, he constituents such as starch, pectin, and cellulose present in the orange peel provide much desired carbon sources for the growth and multiplication of microbes. Soil microorganisms produce extracellular hydrolytic enzymes. Enzymes such as pectinases, celluloses, hemi celluloses bind to pectin, cellulose, hemi cellulosic contents respectively and initiate microbial biodegradation of the film. Hence, results showed biodegradation occurs faster in the existence of extra moisture content than degradation in natural conditions by these results, we can conclude the bio plastic produced using orange peel of navel variety degrades nearly within one week.

Fig No. 7: - Prepared biodegradable bio plastic

4.2 TENSILE STRENGTH:

The bio plastic film's mechanical strength is mainly based on the chemical constituents, structure, and film-forming ability. The formed film's micro tensile strength and elastic properties were determined. It is noted that bio plastics made from various types of starch with glycerol plasticizer without filler has a tensile strength of range 0.22-18.49Mpa. Accordingly, the tensile strength of orange peel-based plastic was 1.72 MPa However the modulus of elasticity of the bio plastics is found to be 54.68Mpa After vigilant interpretation of the results, we can conclude that the bio based plastic film developed using orange peel can exhibit higher elongation properties if its modulus of elasticity can be lowered 30 ASTM D.

Table 3 :- Standard Test Method for Tensile Properties of Thin Plastic Sheeting

	Thickness [mm]	Tensile strength [MPa]	Maximum Load [N]	Load at Break [N]	Yield Strength [MPa]	Young's Modulus [MPa]	Elongation at Break [%]
	1.01	1.71	17.8054	0.46	1.7629	53.95	17.60
1	1.02	1.73	18.6036	0.15	1.8239	55.42	13.14
2	1.02	1.72	18.2045	0.30	1.7934	54.68	15.37
Mean	0.01	0.01	0.56	0.22	0.04	1.04	3.16
Std:deviation	0.70	0.63	3.10	73.39	2.40	1.90	20.54
Coeff:of variation							

4.3 FTIR ANALYSIS:

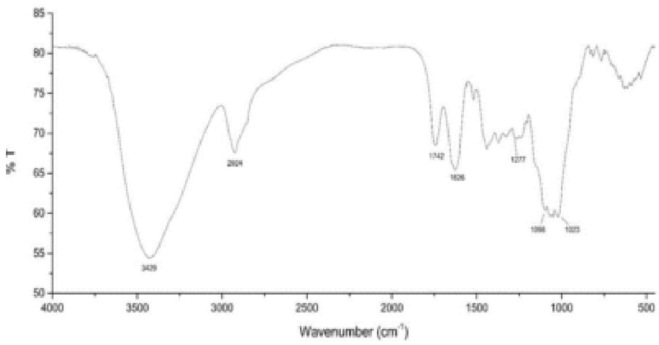


Fig No. 8: - FTIR analysis graph

FTIR measurements for synthesized bio plastic film were carried out to identify the possible biomolecules present in the bio plastic. The result of FTIR analysis of synthesized bio plastic shows as follows: The stretching absorption band centered at 3429 cm–1 represents the OH group. The band observed at around 2924 cm-1 showed carboxylic acids. The peak at 1626 cm–1 is assigned to the C=C stretch of alkene, aromatic or amino acids The band at 1742 cm-1 is related to carboxylic group of esters. The peaks at 1098 cm-1 and 1023 cm-1 are due to the C=O stretching and are characteristic bands of cellulose. The above results are found similar to the report of Pranav et al. which confirms the presence of biomolecules such as alcohol, amine, esters, and carboxylic groups in orange-based biomaterial. The above results are found similar to the report of Pranav et al. which confirms the presence of biomolecules such as alcohol, amine, esters, and carboxylic groups in orange-based biomaterial. The orange peel waste contains mainly cellulose, pectin, lignin, hemicellulose, and they are inevitable sources for renowned biomaterials synthesis. As per the Fig. 7 the peak of 2924 cm-1 32 belonged to carboxylic acids the main source of presence of carboxylic acid in the developed material are cellulose or pectin or lignin. The analyzed film sample also contains amino acids 1626 cm-1 stretching and pertaining to their orange peel derived film can also use for the protein synthesis through biological process. Besides, this the hydroxyl groups in the film sample plays critical part in adsorption of anionic dye impurities. One of the significance observations was made that there were no peak seen between 2220 and 2260 cm-1 which is directly corresponding to the cyanide groups, that certainly confirms that the developed material does not comprise any hazardous materials. The presence of amide, amine and amino groups in the sample indicated they serve as very good sources of nitrogen.

CHAPTER – 5

5. CONCLUSION

In conclusion, this study has demonstrated the feasibility of producing biodegradable plastics from plant parts, specifically focusing on the utilization ofmaterials derived from various plant sources such as orange peels and banana peels. The extraction and processing methods outlined in this research have proven effective in obtaining a biodegradable material that shows promise as an environmentally friendly alternative to traditional plastics. Remember that this process is a simplified version, and the exact procedure may vary based on experimentation and specific conditions. Additionally, while this bio plastic is more environmentally friendly than traditional plastics, its properties may not match those of conventional plastics, and it may have limitations in certain applications. Always prioritize safety and proper disposal practices. The biodegradability of the produced plastics is a significant environmental benefit, potentially addressing the concerns associated with the persistent nature of conventional plastic. The conducted tests on the bio plastic have provided valuableinsights into its properties, including flexibility, strength, transparency, water resistance, and biodegradability. These findings contribute to a comprehensive understanding of the material's performance under various conditions. While the developed biodegradable plastics exhibit promising characteristics, it is important to acknowledge certain limitations. The mechanical properties may still need refinement for specific applications, and further research could explore optimizingthe formulation for enhanced performance. Additionally, the economic feasibilityand scalability of large-scale production should be considered to facilitate the practical adoption of plant-based biodegradable plastics in diverse industries.

The bio-based material produced in the experiment demonstrated good biodegradation with a high moisture content. Biodegradable bio plastics can be just as durable as other bio plastics, as they only disintegrate in specified situations. The tensile strength of the material is determined to be 1.72 MPa, which is in the range of bio plastic created from various types of starch with glycerol plasticizer. According to JIS standards, 1–10 MPa is the ideal tensile strength value. An orange peel-based bio-based substance is therefore thought to meet JIS standards. The modulus of elasticity is discovered to be higher, nevertheless.

Therefore, we can draw the conclusion that the material's flexibility can be enhanced by lowering its Young's modulus. It is also claimed to be noteworthy research because the methodology adopted demands the naturally available resources that to organic waste materials like orange peel and that can be converted to wealth technology. The FTIR analysis was conducted to know about the presence of functional groups in the film, Moreover, it is realized that there are no harmful constituents present in the material. Thus, the developed material is safe to the environment. The presence of carboxylic acid dictates their role in pharmaceutical applications. The presence of the plasticizers has made the film more tangible material. He foremost essential constituent of the bio-based plastic, i.e., pectin and cellulosic fibers, provided the required strength and also ensured biodegradability could be used as short-term packaging material. The bio-based material obtained is promising, although further characterization and improvements are necessary to achieve the desired features such as hydrophobicity. Lastly, bio-plastic production from orange waste can serve as an excellent solution to the challenges raised by the disposal of fruit waste and its effective utilization is highly concern.

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