Production of Biodegradable plastic and eco-friendly sustainable mulching paper using cornstarch and banana peels.

A PROJECT SUBMITTED

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THE UNIVERSITY OF MUMBAI

OF

THE DEGREE OF

BACHELOR OF SCIENCE IN BIOTECHNOLOGY

UNDER THE GUIDANCE OF

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PALGHAR

T.Y. BSc BIOTECHNOLOGY (2023-24)

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DECLARATION

I, Mr. ASHISH .R. VISHWAKARMA, student of T. Y. B. Sc. Biotechnology hereby declares that the project entitled " Production of Biodegradable plastic and eco-friendly sustainable mulching paper using cornstarch and banana peels” submitted by me for the academic year 2023-2024 is based on the actual work carried out by me under the guidance of Asst. Prof. HARDIK.S.CHURI. I further state that this work is original and it has not been submitted, in whole or in part, for any degree, diploma or similar title of any University.

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ABSTRACT

Plastics are detrimental to the environment and human health. Plastic's persistence allows them to alter the habitat, mobility, and health. They decrease biodiversity and species variation in deep ocean habitats. Polystyrene nanoparticles have been demonstrated to be able to cross the blood-brain barrier (BBB) in vivo, which raises the possibility of inflammation, neurological conditions, and even neurodegenerative diseases like Parkinson's and Alzheimer's. To address this issue biodegradable bioplastic is being produced from renewable sources such as starch, cellulose, chitin, pectin, etc. Hence the objective of this research is to develop and produce biodegradable plastic that can substitute the non-biodegradable plastic using starch and banana peel. The synthesis method includes the use of Glycerol which is the major compound that acts as a plasticizer; PVA (polyvinyl alcohol) is used for making starch beads. These bioplastic materials are not only biodegradable and biocompatible but also versatile, with potential applications in various industries including packaging, electronics, automotive, food service, cosmetics, and construction.

Keywords: - Biodegradable plastic, corn starch, starch beads, Banana peel, Mulching paper, Chemical treatment, Glycerol, PVA.

AIM AND OBJECTIVES

Aim: Production of Biodegradable plastic and eco-friendly sustainable mulching paper using cornstarch and banana peels.

Objectives:

1) Making of bio based bioplastic from corn kernels.

2) Improving the shelf life of bio plastic by adding glycerol.

3) Synthesis of starch beads using PVA as the cross linking agent.

4) Conversion of banana peels into eco-friendly biodegradable mulching paper via chemical treatments involving $NaHSO_3$, HCl, glycerol, and NaOH.

INTRODUCTION

There is a growing interest in the biodegradation of plastics due to environmental concerns. Plastics is a synthetic polymeric molecules primarily composed of carbon, hydrogen, nitrogen, oxygen, chlorine, and bromine, are widely used in various industries such as automobile production, space exploration, agriculture, and healthcare which exhibits desirable features like softness, heat seal ability, good strength to weight ratio and transparency.[1]

Petrochemical-based plastics like polyethylene (PE), Polypropylene (PP), Polystyrene (PS) Polyvinyl chloride (PVC), Polyurethane (PUR), Poly ethylene terephthalate (PET), Polybutylene terephthalate (PBT), and Nylons are the most widely used polymers in daily life due to their versatile, light weight, excellent thermal and rheological properties, inexpensive, easy to manipulate and easily formed into diverse products.[2],[6],[12]

We need to talk about plastics. Plastic products have become a convenient tool in many areas of life, and agriculture is no different. Plastics are used for everything from seedling trays and irrigation tubing to pesticide containers and livestock feed bags. However, their proliferation has led to mounting environmental problems that threaten soil health, water quality and human well-being.[3]

In late 2021, the Food and Agriculture Organization of the United Nations (FAO) released a landmark report assessing the use of plastics in agriculture.The report calculated that, in 2019, agricultural value chains used 12.5 million tonnes of plastic products in plant and animal production and 37.3 million tonnes in food packaging.[3]

“We estimated that crop production and livestock sectors together contributed 10 million tonnes, followed by fisheries and aquaculture with 2.1 million tonnes and forestry with 0.2 million tonnes,” said Richard Thompson, FAO Agricultural Plastics and Sustainability Specialist and one of the authors of the report.[3]

“The global demand for greenhouse, mulching and silage films is also projected to increase by about 50 percent by 2030,” he added.[3] The overuse of plastics has led to significant environmental Impacts, with an estimated 34 million tons of plastic produced per year, of which only 7 percent is recycled, while the remaining 93 percent is dumped into oceans and landfills.[2] High-temperature degradation processes like pyrolysis can lead to the emission of toxic fumes. The accumulation of plastic waste poses significant environmental challenges globally, affecting the carbon dioxide cycle, composting processes, and increasing toxic emissions. Researchers are focusing on developing more sustainable plastic materials driven by environmental considerations. Recycling and producing degradable plastics are two key strategies being explored. In recent decades, the plastic industry and the academic community have been together looking for new raw materials to replace the petrochemical polymers, which are produced from nonrenewable resources [6][7]

Bioplastics, including biodegradable and bio-based plastics sourced from various materials like jackfruit, banana peels, cornstarch and more offer environmentally friendly alternatives[9]. Due to its role as a linking matrix between fillers, starch is widely used as the primary biopolymer for producing high-performance and biodegradable biofilms/bio plastic. Its attractiveness in the industrial sector stems from its availability and cost-effectiveness.

Bio-based plastics are made using polymers derived from plant based sources e.g. starch, cellulose, oils, lignin etc [10]. Bio-based polymers can be used to make plastic packaging [11] that behaves like conventional plastic. It can also be used to make biodegradable and compostable plastics. Both types are referred to as bioplastics. Additionally, biopolymers derived from renewable resources such as plants and animals can play an essential role in overcoming the challenges related to the depletion of oil reserves along with the environmental issues related to the increased use of petroleum-based plastics. These polymers can be natural fibers, cellulose, polysaccharides, proteins, lipopolysaccharides, polyhydroxyalkanoates, or glycolipids, which are suitable in environmental applications[5]. Industrial plastic waste continues to add to the problem. Sikkim in 1998 has done a great job in

bringing down the use of plastic, which have commenced bans on plastic. Stop treating plastic as waste and treat it as a recyclable resource like we treat newspapers and yet, our metros continue to super flooding caused by drains choked by used plastic, and animals continue to die in the country by gagging on inadvertent plastic consumption. Now the blame lies on us and citizens to do our bit to save the planet from being choked by untreated plastic. Here’s how we can adopt some basic lifestyle changes that will help clean up the environment, a step at a time. The disposal of plastic waste into new and useful products may be somewhat useful. When performed correctly, this can reduce dependence on land, conserve resources and protect the environment from plastic pollution and greenhouse gas emissions.[4]

The term waste is typically applied to solid waste, sewage like wastewater, hazardous waste and electronic waste. Waste is classified by source and composition. Broadly speaking, waste materials are either liquid or solid in form and their components may be either hazardous or inert in their effects on health and the environment. Plastic waste is one of the major pollutants of solid waste throughout the world. Incineration involves burning of plastic waste which leads to the production of toxic gasses. Recycling is the most important method in which the plastic waste is converted into other usable forms of the plastic. Waste disposal, collection, processing and recycling of waste materials of human society is the biggest task[4]

Approximately 50% of the bioplastics used commercially are prepared from starch. The production of starch-based bioplastics is simple, and they are widely used for packaging applications [15][16]. Cornstarch plastic is increasingly being used in a number of markets and sectors from packaging, food and hospitality, electronics, toys, fashion and textiles[17]

Corn starch, constituting over 85% of global starch production, is the predominant source of commercial starch globally. While other plants like wheat, rice, and potato also contribute to native starch sources, they represent a smaller proportion of global starch production[19][20] The composition of corn granules consists of approximately 70% semi-crystalline starch, with the remainder comprising carbohydrate, protein, oil, and ash.[21] In recent years, there has been a growing interest in starch-based materials for various packaging applications driven by concerns about global warming. [20]

Despite advancements in the biopolymers market, particularly environmental aspects, challenges persist in replacing petroleum-based plastics.[13][14].

Various plasticizers such as fructose, glucose, sucrose, urea, glycerol, triethanolamine, glycol, sorbitol, xylitol have been utilized to optimize biopolymer properties. Studies have shown that different plasticizers impact film properties differently; for instance, fructose at 25% produced optimal features in corn-starch films. Combining plasticizers like glycerol and fructose can offer synergistic effects on film properties. The study aims to explore the effects of glycerol, fructose, and their combination at varying concentrations as plasticizers on corn-starch-based bioplastics. Additionally, efforts will focus on enhancing the moisture barrier properties of corn-starch films for food packaging applications to address their sensitivity to humidity and low moisture barrier characteristics effectively[19].

Bioplastic can be degraded by natural microorganisms such as bacteria, algae, and fungi[8]

ADVANTAGES AND DISADVANTAGES OF BIOPLASTICS

TYPES	ADVANTAGES	DISADVANTAGES
BIOPLASTIC	Sustainable	Costly
	Reduced carbon footprint	Thermal instability
	Reduce energy efficiency	Recycling problem
	Partly based on natural feedstock	brittleness
CONVENTIONAL PLASTIC	Low cost	Based on petrochemical
	Good and excellent technical properties	Difficult to recycle
	Can save energy and resources	Mostly not biodegradable
	Thermal recycling possible	Uncontrolled combustion can release toxic substances

[2]

REVIEW OF LITERATURE

1. **Sultan, N. F. K., & Johari, W. L. W. (2017). The development of banana peel/corn starch bioplastic film: a preliminary study.** ***Bioremediation Science and Technology Research*****, https://doi.org/10.54987/bstr.v5i1.352**

   This study explores the creation of bioplastic films from banana peel and corn starch, aiming to harness agricultural waste for sustainable material production. By combining these two biopolymers, the researchers assessed various film formulations, finding that the 4% corn starch film exhibited the highest tensile strength, while the 3% corn starch films showed resistance to water absorption. Characterization analyses confirmed the successful integration of corn starch into the banana peel matrix, suggesting a promising approach for developing sustainable bioplastics.

2. **Arifa Shafqat et al.(November 21, 2020) carried out PRODUCTION AND CHARACTERIZATION OF RICE STARCH AND CORN STARCH BASED BIODEGRADABLE BIOPLASTIC USING VARIOUS PLASTICIZERS AND NATURAL REINFORCING FILLERS.**

   Arifa Shafqat et al. investigated biodegradable bioplastics made from rice and corn starch, enhanced with natural fillers like eggshells and rice hulls. They varied starches, plasticizers, and filler amounts to evaluate properties like moisture content, water absorption, solubility, biodegradability, tensile strength, and Young's modulus, also conducting FT-IR analysis. The study explored RTV silicone coating for hydrophobicity. Findings emphasized the role of starch sources, plasticizers, and fillers in bioplastic properties, highlighting their eco-friendliness and biodegradability as promising alternatives to traditional plastics.

3. **M. K. Marichelvam 1,Mohammad Jawaid and Mohammad Asim (2019) carried out a study based on Corn and Rice Starch-Based Bioplastics as Alternative Packaging Materials. The results show the suitability of rice and corn-based thermoplastic starch for packaging applications.**

   The researchers investigated the suitability of corn and rice starch-based bioplastics for packaging. Different compositions of starch, glycerol, citric acid, and gelatin were used to produce bioplastic samples. The addition of rice starch improved tensile properties while reducing water absorption and solubility. The best sample underwent thorough analysis, including thickness testing, biodegradability assessment, SEM analysis, hydrophilicity testing, thermogravimetric analysis, and sealing properties evaluation. The findings affirmed the suitability of rice and corn-based thermoplastic starch for packaging applications.

4. **Cindy Li Yin Lee, Wan Sieng Yeo (2021) carried out a study on A Basic Characterisation Study of Bioplastics via Gelatinization of Corn Starch. where it was found that the ratio of corn starch and glycerol has the highest biodegradation rate and can be easily degraded by ethanol.**

   The study aimed to create eco-friendly bioplastics to replace petroleum-based plastics, testing various corn starch to glycerol ratios. Fourier Transformation Infrared Spectroscopy identified polyester functional groups in all bioplastics, while thermal analysis showed they decompose between 34°C to 504°C. The 1:0.5 corn starch to glycerol ratio demonstrated superior biodegradability and lower water retention, suggesting potential for fertilizer coatings due to improved degradation in soils and solubility in ethanol, acetone, and oils. Overall, the research suggests promising applications for corn starch-based bioplastics in environmentally sensitive contexts.

5. **LC de Azevedo, S Rovani, JJ Santos… - ACS Applied Polymer …, (2020) Biodegradable films derived from corn and potato starch and study of the effect of silicate extracted from sugarcane waste ash. The results suggest that sodium silicate solution obtained from renewable sources can be incorporated into starch-based bioplastics for production of biodegradable packaging with antifungal activity.**

   The study aimed to develop environmentally friendly packaging that inhibits fungal growth. They utilized a sugarcane waste-derived liquid to create starch-based plastic, testing its strength and biodegradability. Corn starch plastic outperformed potato starch plastic, and adding the liquid strengthened both. Corn starch plastic degraded over 40 days, while potato starch degraded in 5 days. Additionally, the liquid prevented fungal growth on both plastics. This suggests potential for environmentally-friendly packaging with fungal resistance.

6.

7. **Rowen Lim, Peck Loo Kiew, Man Kee Lam, Wei Ming Yeoh, Mui Yen Ho(2021) Corn starch/PVA bioplastics—The properties and biodegradability study using *Chlorella vulgaris* cultivation. This revealed that *C. vulgaris* showed promise as a candidate for breaking down the bioplastic films when grown as a heterotroph.**

   The study aimed to develop eco-friendly bioplastics by blending gelatinized corn starch with polyvinyl alcohol (PVA) through solution casting. Tensile tests showed increased strength with higher PVA content. Despite changes in starch content, water vapor transmission rate remained consistent, while PVA increased film solubility in water. Starch exhibited greater water absorption, swelling significantly. Fourier transform infrared (FTIR) analysis revealed no significant chemical interaction between starch and PVA. Pure starch films degraded minimally after 3 days in soil, while water uptake turned PVA films into gel-like substances. Chlorella vulgaris favored PVA as a substrate, hinting at its potential for bioplastic film degradation as a heterotroph.

8. **S. Anggraeni, A.B.D. Andiyanto, A.M. Nurjami, S. N. Hofifah, S. R. Putri, G. C. S. Girsang, M. Fiandini(2021) Palm oil and cinnamon(anti-microbial agent) on the physicochemical, mechanical, and biodegradation properties of micrometer-sized cornstarch-based bioplastic.The result obtained so indicate that the addition of palm oil increased the biodegradation rate whereas the antimicrobial amount in the cinnamon reduced the biodegradability of bioplastic.**

   The study investigated how palm oil and cinnamon affect the properties of cornstarch-based bioplastic, focusing on physicochemical, mechanical, and biodegradation aspects. Cornstarch was mixed with water, glycerol, acetic acid, and cinnamon, then heated and supplemented with varying amounts of palm oil. Characterization methods including FTIR, digital microscopy, puncture and compressive tests, and biodegradability assessments were conducted. Adding 1.90% palm oil improved mechanical properties but accelerated biodegradation due to its unsaturated fatty acids. Conversely, cinnamon's antimicrobial properties slowed biodegradation. This research highlights bioplastics as eco-friendly alternatives to conventional plastics, while showing the complex effects of additives like palm oil and cinnamon on bioplastic properties.

RATIONALE

This research aims to identify and replace traditional plastics with environmentally friendly alternatives, since traditional plastics are negative for the environment and take a long time to degrade. This led to the use of corn starch based bioplastics.

Bio plastics are being used by architects and engineers to design eco-friendly structures, from big houses to furniture, contributing to the creation of a more sustainable global community. Bio plastics are used in the automotive industry to create door panels, dashboards, seats, carpets, and other components and accessories. Compared to ordinary plastics, they are more aesthetically beautiful and environmentally benign.

Bio plastic also has a great importance in the agricultural sector in the form of mulching paper. Furthermore, the production of starch beads has an important role from replacing the petroleum based plastic to reducing carbon footprint. Biodegradable polymers can be produced from corn starch, a renewable resource, which reduces energy consumption and greenhouse gas emissions compared to petroleum-based plastics. Aside from improving soil quality, the research aims to reduce plastic waste and enhance soil quality by turning banana peels into mulching sheets. A key objective of this research is to promote environmentally friendly packaging alternatives to conventional plastics.

MATERIALS AND METHODS

Requirements:

1) Extraction of starch from corn kernels

Sample	Corn kernels (100gm)	100gm
Chemicals	1)Distilled water	
	2)8% Acetone	
	3)0.2% NaOH	
Glassware	1)beakers	500ml:4
	2)droppers	2
Miscellaneous	1)Muslin cloth	
	2)weighing machine	
	3)Mortar & pestle	
	4)Hot air oven at 45°c	

Procedures:

1. Extraction of starch from corn

Weigh 100 gm of corn kernels

⇩

Wash and blend using mortar & pestle to form a paste

⇩

Filter it using muslin cloth & wash the residue with 0.2% NaOH

⇩

To the filtrate add 5 ml of 80% Acetone mix it properly and allow it to stand for 1 hour

⇩

Non purified scratch will settle down and decant the upper liquid.

⇩

Wash it again with D/W and after 30 min decant the liquid part

⇩

Repeat this procedure for 2 to 3 times

⇩

Keep the extracted starch in hot air oven at 45˚c for 24 hours

⇩

Measure the starch yield and calculate the % yield.

<u>CALCULATION</u>

Starch yield = **9.255gm**

% yield = [actual yield / theoretical yield] x 100

= [starch yield / amount of starch in 100gm of corn kernels] x 100

2) Synthesis of bio plastic from corn starch

Sample	Obtained Corn starch	
Chemicals	1)glycerol	
	2)acetic acid/vinegar	
	3)distilled water	
Glasswares	1)beaker	1
	2)pipettes	2ml:1
		0.5ml:1
		5ml:1
	3)glass rod	1
miscellaneous	1)asbestos sheet	
	2)hot air oven at 80˚c	

<u>2) Synthesis of bio plastic from corn starch</u>

Take a beaker and add 1.5gm of corn starch in it.

⇩

To this add 0.25ml of glycerol + 1 ml of acetic acid + 6 ml of distilled water

⇩

Stir the mixture properly until the mixture appears milky white in color.

⇩

Now the beaker was allowed to be heated until the mixture formed a thick gel.

⇩

Spread it on the asbestos sheet.

⇩

Allow it to dry in Hot air oven at 80℃ for 3 hours.

- Synthesis of starch beads using corn starch

sample	Corn starch	5gm
chemicals	1) PVA(poly vinyl alcohol)	2.5gm
	2) Distilled water	30ml
	3) Acetic acid	5ml
	4) Chilled water	
glasswares	1) beaker	1
	2) glass rod	1
miscellaneous	1) burner 2) asbestos sheet 3) wire gauge 4) syringe 5) magnetic stirrer	

<u>PROCEDURE</u>

Weigh 5gm of corn starch in a beaker

⇩

Add 2.5gm of PVA (poly vinyl alcohol) and mix it properly on magnetic stirrer

⇩

Add 5 ml of Acetic acid and mix it properly

⇩

Then add 30 ml of distilled water so as to mix it thoroughly until milky white color appears.

⇩

Put it on burner and continue to heat until it form thick gel (low viscous)

⇩

Take the gel into a syringe and transfer it to a beaker containing chilled water.

⇩

A small spherical shape droplets will form that's the starch beads.

- Synthesis of mulching paper using banana peels

sample	Banana peel	100gm
chemicals	1) 0.2M $NaHSO_3$	300ml
	2) Distilled water	1L
	3) 0.5N HCL	3ml
	4) Glycerol	2ml
	5) 0.5N NaOH	3ml
glassware	1) beakers	
	2) pipettes	3ml—2
		2ml---1
	3) glass rod	
miscellaneous	1) burner	
	2) weighing lance	
	3) mortar and pestle	
	4) asbestos sheet	
	5) hot air oven at 120℃	

Procedure

Take 100 gm banana peel and cut into small pieces

⇩

Dip the peels into 0.2M $NaHSO_3$ and left it for 45 minutes

⇩

Discard the solvent and place the peel in beaker filled with D/W

⇩

Boil for 30 min on medium flames

⇩

The water is than removed and the pees were placed on the filter paper to dry for about 30 minutes

⇩

After 30 minutes peels were blended using mortar and pestle to make homogeneous paste

⇩

Take 25 gm of the paste in a beaker and add 3 ml of 0.5N HCL, stirred the mixture properly

⇩

Add 2 ml of Glycerol and stir it then add 3 ml of NaOH and mix it properly

⇩

Spread the mixture on asbestos sheet and keep it in hot air oven at 120℃ for 30 minutes.

<u>INSTRUMENTS USED:</u>

1) Weighing Balance:

Principle*:*

The principle behind weighing balances is based on the concept of balance of weight. The object on the pan downs it with a force equal to mg, where m is the mass of the object and g is the acceleration due to gravity. The electronic balance uses the electromagnetic force to return the pan to its original position. The electronic current required to generate this force is proportional to the mass displayed on the digital readout.

Applications :

1. Determination of weight of an object

2) Hot Air Oven:

Principle::

When electricity is passed through the heating coils, the electrical energy is converted to heat energy. The temperature inside the oven is controlled by the thermostat. There is forced air circulation in the hot air oven. It works by heating the oven and using a fan to move the hot air around. As it is a universal scientific fact that in any chamber, the hot air rises above. So by utilizing this principle, when the hot air reaches the top it is recirculated to the bottom by the fan installed inside the chamber. Thus, the hot air is kept moving around at a consistent temperature throughout the oven.

Applications:

1. Drying of glassware.

2. Dry sterilization of syringes and needles.

3. Heating of chemicals used for the preparation of primary standards.

1) Magnetic stirrer

Principle*:*

The principle of a magnetic stirrer is based on the use of magnetic fields to induce rotational motion in a stir bar, which then stirs and mixes liquids within a container. When the magnetic stirrer is turned on, it generates a rotating magnetic field near its base, usually through an electromagnet or permanent magnet. This magnetic field interacts with a magnetic stir bar placed in the liquid, causing it to rotate and create a vortex in the liquid. This vortex promotes thorough mixing of the contents in the container, ensuring uniform distribution of components and facilitating chemical reactions or physical processes such as dissolution or emulsification.

APPLICATION:

1. Chemical synthesis: They mix reagents and solvents during chemical reactions, improving reaction efficiency.
2. Sample preparation: In biology labs, they dissolve samples like cell cultures or proteins for analysis.
3. Titration: They mix titrant and analyte solutions continuously for accurate results.
4. Dissolution testing: In pharmaceuticals, they simulate gastrointestinal conditions by stirring drug formulations.

RESULT AND DISCUSSION

1) synthesis of bioplastic from corn starch and starch beads

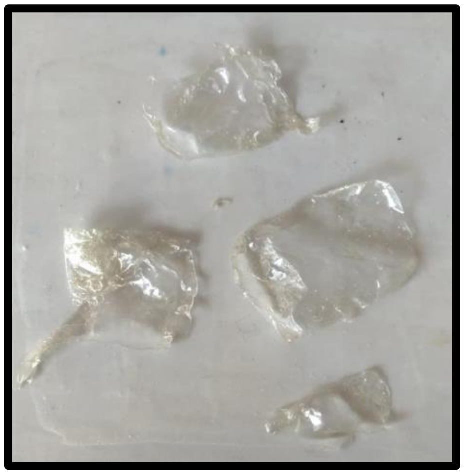
1.1) Separated Corn kernels

The corn kernels were obtained from the Palghar market. It is the important material which is needed in the synthesis of cornstarch.

1.2) Synthesis of Starch from corn kernels

The corn kernels were treated with NaOh and Acetone which helps in disrupting the cell wall and removing non-scratch components thereby allowing the pure extraction of starch.The percentage yield of starch was calculated to be 37.02%.

1.3) Synthesis of bio plastic from corn starch



The treatment of cornstarch with glycerol, acetate and distilled water along by heating the mixture and incubating for 3 hours at 80□c results in the formation of bioplastic.

1.4) synthesis of starch beads

Mixing PVA (Polyvinyl Alcohol) and acetate with cornstarch, and then continuously heating and slowly introducing the resulting semisolid liquid into chilled water, results in the creation of starch beads.

2) Mulching paper from banana peel:

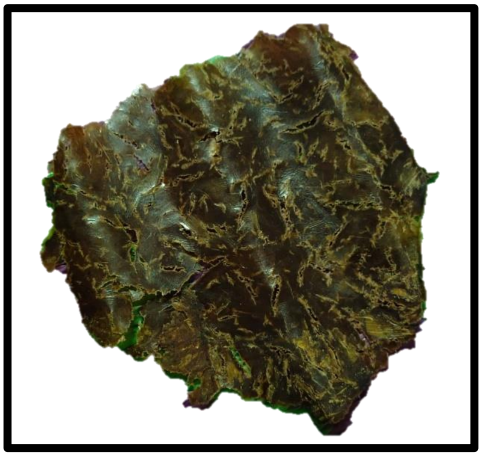
2.1) banana peel

banana peel being the important sample in the synthesis of mulching paper.

2.2) banana peel paste

Subjecting banana peels to heat treatment alongside NahSO3 and distilled water results in the creation of banana paste.

2.3) synthesis of mulching paper



The mixture of banana peel paste is permitted to undergo a reaction with glycerol, hydrochloric acid, and acetate in order to produce environmentally-friendly mulching paper.

CONCLUSION

This research has the potential use of cornstarch and bio waste , banana peel for the synthesis of bio plastic, starch beads and mulching paper. The use of glycerol in the synthesis of both bio plastic and mulching paper has an efficient role as a plasticizer which enhances the efficiency and durability of both the products. Further testing should be employed for enhancing the efficiency of bio plastic as well as mulching paper such as tensile strength, water absorption capacity, biodegradation rate, Solubility test. Bioplastic and biodegradable mulching paper can be an alternative of petroleum based plastic thereby reducing the carbon footprint.

FUTURE PROSPECT

1. Environmental sustainability: Biodegradable plastics from cornstarch and banana peels offer a green alternative to regular plastics, cutting down on fossil fuel use and reducing plastic waste in landfills and oceans.
2. Agricultural benefits: Using banana peels for mulching paper helps farmers save money and improves crop health by keeping soil moist, suppressing weeds, and regulating soil temperature.
3. Circular economy: Repurposing banana peels for mulching paper and combining them with cornstarch creates a circular economy, promoting resource efficiency and sustainable farming practices.
4. Market demand: Growing consumer awareness and demand for eco-friendly products are driving interest in biodegradable plastics and sustainable mulching paper, creating market opportunities for industries and retailers.
5. Innovation and research: Ongoing research in bioplastics and sustainable materials can lead to improved production methods and new applications, expanding the range of eco-friendly products derived from agricultural waste.

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