

**VALORISATION OF *Solanum tuberosum* AND  
*Musa paradisiaca* PEEL WASTE INTO  
FUNCTIONAL BIOPLASTIC**

**Thesis submitted in  
Partial Fulfilment of the Requirements for the  
Degree of  
MASTER OF SCIENCE**

**in  
BIOTECHNOLOGY**

**by  
JYOTISNA**

**24/MSCBIO/24**

**Under the supervision of  
PROF. JAI GOPAL SHARMA  
Department of Biotechnology  
Delhi Technological University**



**To the  
Department of Biotechnology  
DELHI TECHNOLOGICAL UNIVERSITY  
(Formerly Delhi College of Engineering)**

**Bawana Road, Delhi- 110042**

**May, 2026**



## **DELHI TECHNOLOGICAL UNIVERSITY**

**(Formerly Delhi College of Engineering)**

**Shahbad Daulatpur, Main, Bawana Road, Delhi-42**

### **CANDIDATE'S DECLARATION**

I, Jyotisna, 24/MSCBIO/24 of MSc. Biotechnology, hereby certify that the work which is presented in the thesis entitled “**Valorisation of *Solanum tuberosum* and *Musa paradisiaca* peel waste into Functional Bioplastic**” which is submitted by me to the Department of Biotechnology, Delhi Technological University, Delhi in partial fulfilment of the requirements for the award of the degree of Master of Science in the Department of Biotechnology, Delhi Technological University is an authentic record of my own work carried out during the period from January to April under the supervision of Prof. Jai Gopal Sharma.

The matter presented in the thesis has not been submitted by me for the award of any other degree of this or any other Institute. The work has been accepted in SCOPUS conference with the following details.

**Candidate's Signature**

**Date:**

**Jyotisna**

**Place**



# DELHI TECHNOLOGICAL UNIVERSITY

(Formerly Delhi College of Engineering)

Shahbad Daulatpur, Main, Bawana Road, Delhi-42

## CERTIFICATE BY THE SUPERVISOR

Certified that Jyotisna (24/MSCBIO/24) has carried out their search work presented in this thesis “**Valorisation of *Solanum tuberosum* and *Musa paradisiaca* peel waste into Functional Bioplastic**” for the award of Master of Science from Department of Biotechnology, Delhi Technological University, Delhi, under my supervision. The thesis embodies results of original work, and studies are carried out by the student herself and the contents of the thesis do not form the basis for the award of any other degree to the candidate or to anybody else from this or any other University/Institution.

Date:

Signature

Prof. Jai Gopal Sharma

Supervisor

Department of Biotechnology

Delhi Technological University

Signature

Prof. Yasha Hasija

Head of the Department

Department of Biotechnology

Delhi Technological University

## **ACKNOWLEDGEMENT**

**I would like to express my gratitude towards my supervisor, Prof. Jai Gopal Sharma, for giving me the opportunity to do research and providing invaluable guidance throughout this research. His dynamism, vision, sincerity, and motivation have deeply inspired me. He has motivated me to carry out the research and to present my work as clearly as possible. It was a great privilege and honor to work and study under his guidance. His insightful feedback pushed me to sharpen my thinking and brought my work to a higher level.**

**I express my kind regards and gratitude to Prof. Yasha Hasija, Head of Department, Department of Biotechnology, Delhi Technological University and all the faculty members for helping in my project. I would also like to thank Ph.D. scholar Ms. Akansha and Ms. Shatrupa for their continuous assistance during my practical work. I am extremely grateful to my family and friends who guided and helped me in every step of the research.**

**Finally, I am thankful to all the people who have supported me to complete my research work directly or indirectly.**

**JYOTISNA**

**24/MSCBIO/24**

## ABSTRACT

The aim of this study is to synthesize high intensity, flexible bioplastic by upcycling commercial chip industry waste peels of *Musa paradisiaca* and *Solanum tuberosum* as a eco-friendly alternative to petroleum based plastics. The chips-industrial waste, banana peels, and potato peel waste generated in huge amounts, every year and are rich in starch.

Firstly, the peels from raw *Musa paradisiaca* and *Solanum tuberosum* are chopped and dried, ground into fine powdered form, and dissolved them into an alkaline solution used bio-based binding agents for casting. Allow dried our sheets in oven for overnight at 50-70°C. This experiment used glycerol as a plasticiser to increase its flexibility and Sodium Hydroxide (NaOH) for degrading lignin, hemicellulose, cellulose, and other complex polymers in plant biomass.

Further, addition of Sodium alginate along with glycerol and carboxymethyl cellulose (CMC) as a binding agent enhances the overall flexibility of the material . It showed heat resistance, water resistance and microbial growth resistance properties to a greater extent. The blending and nanostructure is investigated and confirmed by FTIR Spectroscopy.

The study proves that a combination of Raw Banana peels, which are rich in cellulose, hemicellulose, lignin, polyphenol and pectin, leads to high flexibility and elongation. Whereas potato peels, which contain starch like amylose and amylopectin contribute towards high tensile strength and elasticity. This project is support the India's Mission 2047 by promoting the waste valorisation and sustainable materials development under the framework of green technology as it recycling food waste into a valuable product biodegradable bioplastic.

## TABLE OF CONTENT

|   |       |
|---|-------|
| Title   | 1     |
| Candidate's declaration   | 2     |
| Certificate   | 3     |
| Plagiarism Verification   | 4     |
| Acknowledgement   | 5     |
| Abstract  | 6     |
| <b>Table of Contents</b>  | 7     |
| <b>List of figures</b>  | 8     |
| <b>List of symbols and abbreviations</b>                            | 9     |
| <b>CHAPTER 1: INTRODUCTION</b>                                      | 10    |
| <b>CHAPTER 2: LITERATURE REVIEW</b>                                 |       |
| 2.1 Bioplastics   | 11    |
| 2.2 Sources of Bioplastic   | 11    |
| 2.3 Physical, Mechanical and Thermal Characteristics of Bioplastics | 11    |
| 2.4 Properties of Banana Peels                                      | 12    |
| 2.5 Properties of Potato Peels                                      | 12    |
| 2.6 Factors Influencing the production of Bioplastics               | 12-13 |
| <b>CHAPTER 3 : MATERIAL REQUIRED AND METHODOLOGY</b>                |       |
| 3.1 Experimental apparatus  | 14    |
| 3.2 Reagents and raw materials                                      | 14    |
| 3.3 Sample Extraction and Preparation                               | 15-17 |
| 3.4 Steps   | 18    |
| 3.5 Preliminary screenings  | 19    |
| <b>CHAPTER 4: RESULT AND DISCUSSION</b>                             |       |
| 4.1 Morphology and physical properties                              | 20    |
| 4.2 Chemical Structure verification                                 | 21    |
| 4.3 Mechanical Properties   | 21    |
| 4.4 Environmental and Barrier Resistances                           | 21    |
| 4.5 Water Resistance  | 22    |
| 4.6 Resistance to Microorganisms                                    | 22    |
| 4.7 Sustainability Framework and Relevance to Industry              | 23    |
| <b>CHAPTER 5: CONCLUSION</b>  | 24-25 |
| <b>CHAPTER 6: REFERENCES</b>  | 26-27 |
|   |       |

## LIST OF FIGURES

| <b>FIGURES</b> | <b>DESCRIPTION</b>   |
|----------------|--|
| Figure 3.1     | Dried <i>Solanum tuberosum</i> (Potato) Peels  |
| Figure 3.2     | Powder of dried <i>Musa paradisiaca</i> (banana) peels.  |
| Figures 3.3    | Powder of Dried <i>Solanum tuberosum</i> (Potato) peels  |
| Figure 3.4     | The picture shows a beaker containing a powdered mixture of dried potato and banana peels dissolved in water.              |
| Figure 3.5     | After heating, mixture of dried potato and banana peels dissolved in water.  |
| Figure 3.6     | Illustrates the methodology of the synthesis of bioplastic from <i>Solanum tuberosum</i> and <i>Musa paradisiaca</i> peel. |
| Figure 4.1     | Bioplastic synthesised from powder of Green banana peels and Potato Peel   |
| Figure 4.2     | Fire test  |
| Figure 4.3     | FTIR analysis of bioplastic sheet obtained from combination of 75% Raw Banana peels and 25% Potato Peels                   |

## **LISTS OF ABBREVIATIONS**

CMC- Carboxymethyl Cellulose

PHB- polyhydroxybutyrate

FTIR-Fourier-Transform Infrared

NaOH- Sodium hydroxide

HCl- Hydrochloric Acid

RT- Room Temperature

PLA- Poly Lactic Acid

# CHAPTER 1

## Introduction

Plastic pollution has become a huge environmental problem today, motivating the whole world to attention toward sustainability and circular bio economy (Vatieri, 2025). Ever since 1950s, petroleum-based plastics have been predominantly, adapted due to their cheap prices and longevity. As they are non-biodegradable, there is a huge demand for greener and cleaner alternatives (Pandey, 2026). The idea of bioplastics came into picture in the early 1920s, when French scientist Maurice Lemoigne discovered polyhydroxybutyrate (PHB) from bacterial fermentation but bioplastic breakthrough innovation were not considered much, due to boom of cheap petrochemical polymers.

In recent years, the definition of sustainable materials has shift from just bio-degradability to entire life cycle of the feedstock, to ensure that the production of bioplastics does not compete with food security or farmland (Kakadellis & Harris, 2020). Modern research is contributing in converting use of agricultural and food processing by-products, industrial waste into valuable polymeric matrices (Vatieri, 2025). Structural polysaccharides can be extracted from tuber and fruit processing industries (Caliskan, 2025).

Large amounts of organic waste is produces from commercial chip and snack food industry, which usual kept in landfills. This thesis focuses on the valorisation of commercial chip industry waste, specifically from *Solanum tuberosum* and *Musa paradisiaca* peels, and make a highly functional, eco-friendly biofilm as an end product, which can be used as bioplastic. Amylose-rich (starch) from Potato peels (Rani, 2026), and lignocellulosic fibres and flours from banana peels, can be readily cast into structural films (Alcivar-Gavilanes et al., 2022). The blending of these two waste products together created a highly functional biofilm In which the banana peels contributed toward elastic flexibility , potato peels increase the overall tensile strength of biofilm .

The refinement of these bio-composites is done, the raw peels are chopped and dried, then converted into powder and treated with alkaline Sodium hydroxide (NaOH), which degrade the rigid lignin and cellulose components and washed with distilled water to remove extra NaOH. The extracted polymers are then plasticized with glycerol and stabilised by carboxymethyl cellulose (CMC) to retain structural integrity and flexibility. The resulting material oven dried between 50–70°C followed by casting in order to get a dark unbleached biofilm material. Which can be used as a bioplastic as it has resistance toward heat, water and microbial attack. The molecular structure of the bioplastic was confirmed by Fourier-Transform Infrared (FTIR) spectroscopy. The present research is a direct linked with sustainable growth and contributes to India under Mission 2047 by promoting waste valorization and green material development.

## **CHAPTER 2**

### **Literature Review**

#### **2.1 Bioplastic**

Today's modern industrial world is built upon Petrochemical synthetics. For nearly a century, we have been stuck on that choice between microplastics, absolute environmental permanence, and finite fossil fuels (Kakadellis & Harris, 2020). These biomass-derived, biodegradable bioplastics work around the circular economy (Vatieri, 2025).

Maurice Lemoigne isolated polyhydroxybutyrate (PHB) from bacterial lipids for the very first time in 1926. But the market is more inclined toward cheap oil-based polymers boom the market and escaped bio-based research for fifty years due to their expensive downstream steps. Even now, A few pure microbial variants like polyhydroxyalkanoates still face a downfall because expensive extraction.(Danial et al., 2021).

So, now researchers focus entirely on low-impact, zero-burden carbon (Pandey, 2026). This means intercepting waste streams from manufacturing lines rather than burning up fertile farmland meant for feeding people (Kakadellis & Harris, 2020). It's a massive shift. Yet, global checks on single-use packaging will force rapid commercial scaling (Rodriguez et al., 2024).

#### **2.2 Sources of Bioplastics**

Feedstocks can be classified into three generations based on Origin. First-generation sources: They are straight from food supplies like corn, cane, and cassava. They are not good for long-term sustainability as raising up food prices and taking arable land.

Second-generation processing shifts to non-food biomass, agricultural leftovers, and municipal food waste (Vatieri, 2025). This category feeds on materials like tuber skins, fruit epicarp discards, and processing effluents waste, and agricultural waste (Caliskan, 2025). It avoids the food-versus-fuel trap completely and utilises tons of organic wastes (Ebrahimian et al., 2022).Our work focuses strictly on second-generation materials. The raw Starch rich chips industry, discarded peels of potato and banana chip production are processed further in order to synthesise a biofilm out of it.

Third-generation lines bypass land entirely by cultivating algae and specialized wastewater microbes.

#### **2.3 Physical, Mechanical and Thermal Characteristics of Bioplastics**

A bioplastic synthesis is completely based upon its raw material thresholds. Whereas the performance depends entirely on physical, mechanical, thermal, and barrier properties.

##### **2.3.1 Mechanical Properties**

Mechanical performance relies on two parameters: tensile strength, which is the maximum stretch a material tolerates, and elongation at rupture, a measure of raw toughness before failure. If only starch rich material used it make the matres is brittle and fails under tension. Because of this, cross-linking agents, plasticisers, and structural fibres are added to it to make it viable (Rani, 2026).

### 2.3.2 Hydrophilicity or Hydrophobicity of Starch-Based Bioplastics

Starches and celluloses are packed with free hydroxyl (-OH) groups. Consequently, raw, unmodified bioplastics love water. This hydrophilic nature means they absorb moisture rapidly and swell up in wet conditions (Shafqat et al., 2021). But this hydrophilic nature can be neutralised by blending in hydrophobic bio-binders and mineral fillers.

### 2.3.3 Biodegradability

Petroleum plastics are highly non perishable. Instead bio-based polymers are biodegradable in nature, microbes break them down naturally into carbon dioxide, water, and stable biomass (Danial et al., 2021). The degradation clock depends mostly on the polymer's internal crystallinity and the microbial density of the surrounding soil.

### 2.3.4 Chemical Structure Confirmation

Fourier-Transform Infrared (FTIR) spectroscopy verifies the chemical structure. We use this technique to check the carbohydrate retention, trace cross-linking, and monitor shifts in hydrogen bonding (Rani, 2026).

## 2.4 Properties of Banana Peel

Banana peel waste specifically from *Musa paradisiaca*, contains massive reserves of cellulose, hemicellulose, pectin, and starch (Sultan & Johari, 2021). Quality of Resulting product depend on processing steps . The dried peels into a coarse, fibrous flour (Alcivar-Gavilanes et al., 2022) , boil and blend them into a thick, gelatinized paste (Al-Qadri, 2025). Lignocellulosic fibres are major component of the banana , their dense fibre network yields high mechanical flexibility and excellent elongation characteristics. Adding the alkali solutions like sodium hydroxide (NaOH) strips away the outer defences and breaks down the rigid lignin and hemicellulose seals, making the raw cellulose fibres for film casting (Kossalbayev et al., 2025).

## 2.5 Properties of Potato Peel

Industrial chip manufacturing lines dump potato peel waste, *Solanum tuberosum*, in landfills by tons. It's a massive processing byproduct, but it serves as a cheap, incredibly rich reservoir of high-grade starch (Ebrahimian et al., 2022).

**Starch Extraction Process:** Isolating starch from industrial potato peel waste requires a modified wet sedimentation process. It yields a highly consistent, pure product (Rani, 2026). This recovered starch contains 21.2% amylose and 78.8% amylopectin, which creates a highly crystalline, semi-continuous matrix (Rani, 2026).

**Structural Functions:** The tightly packed amylose chains give pure potato peel starch excellent tensile strength and rigidity. So it turn easily into biofilm.

**Performance Limitations:** Raw potato starch is brittle in nature. It suffers from high water vapor permeability and degraded very quickly in the soil. (Jinnah et al., 2022; Al-Qadri, 2025).

## 2.6 Factors Influencing the Production of Bioplastics

### 2.6.1 Plasticizers

Hydrogen bonds are the main force that act between raw starch and cellulose molecules and kept them together in a rigid grip . These interactions are disturbed by introducing small, hydrophilic plasticizer molecules between the polymer chains which act on then and forces them apart (Othman et al., 2021). Among them Polyol plasticizers like liquid glycerol carry

multiple hydroxyl groups, which easily bind with interact and allow the molecular chain disturb.(Shafqat et al., 2021).

If Too much glycerol is used then it will spoil the experiment . High concentrations of Glycerol make rapid water absorption and disturb the integrity of the material (Shafqat et al., 2021). Whereas the biofilm may gain structural support but make it rigid enough to loose flexibility, if Sorbitol is used. (Rani, 2026).

#### 2.6.2 Concentration and Efficiency of Bi-binders

It is very important to add the materials like CMC and Sodium Alginate for keeping the matrix uniform and stable, these are bio-binders They cross-linked networks between the potato starch particles and banana fibres contributing toward the resulting flexible, smooth, and moisture resistant.

#### 2.6.3 Bio-Pre-treatment Conditions (Alkali Digestion)

To breaking the lignocellulosic segments it is very important that the mild alkali like Sodium hydroxide treatment is given to the solution. (Kossalbayev et al., 2025). The process put away non-cellulosic junction of lignin, making the structure free . It is also very important use the right concentration of NaOH. The proper washing after this is also very important to remove the excess of it ,after degradation. Very high concentration of NaOH disturb the tensile strength of final synthesised material.

#### 2.6.4 Temperature and Drying Cycle Profiles

Drying temperatures play very important role to make mixture gelatinizes and remove extra water. Keeping oven temperature steady at 50-60 degree celcius is Important for evaporation. It prevents thermal breakdown and cracking of the structure.

## CHAPTER 3

### Material required and Methodology

#### 3.1 Experimental apparatus:

- laboratory blender or motor and pastel
- beaker 100mL and 250mL
- Hot plate with a magnetic stirrer or manual glass steering rod.
- Analytical balance.
- PH meter or indicator strip .
- thermometer
- Non-stick casting surface (silicon mat Teflon sheet or glass Petri dishes)
- laboratory drying oven

#### 3.2 Reagent and raw materials;

- Biopolymer matrix : 15.0g banana peels and 5.0g potato peels.
- Hydrolysing Agent: 1.8 mL Hydrochloric Acid HCl (0.1 M -0.5 M)
- Neutralizing Agent: 1.8 mL Sodium Hydroxide NaOH 0.1 M 20.5 M
- plasticiser 1.2 ML glycerol
- Reinforcing polymer : 1.8 ML carboxymethyl cellulose solution
- Solvent distilled water

#### 3.3 Sample Extraction and Preparation



Figure 3.1 Sun-dried, *Solanum tuberosum* (Potato) Peels.



Figure 3.2 Powder of Sun-dried *Musa paradisiaca* (banana) peels.



Figure 3.3 Powder of Sun-Dried *Solanum tuberosum* (Potato) peels.

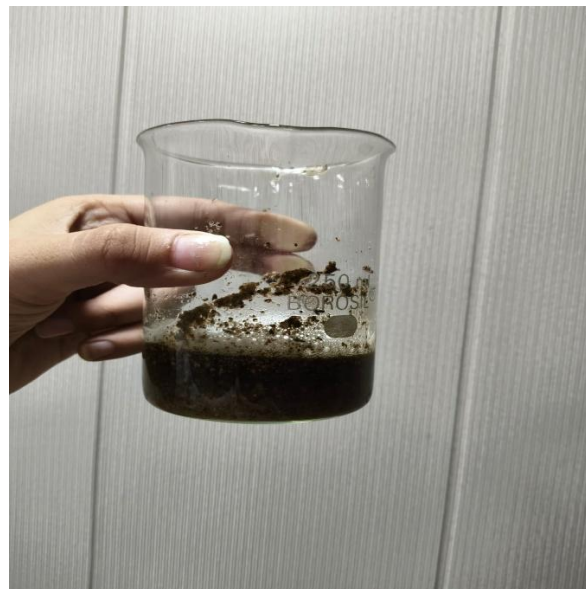


Figure 3.4 The picture shows a beaker containing a powdered mixture of dried potato and banana peels dissolved in water.



Figure 3.5 After heating, mixture of dried potato and banana peels dissolved in water.

Pre-treatment:

- **Washing:** The raw banana peels should be washed with distilled water to remove the dirt and other contamination.
- **Cutting:** Cut the peels into small pieces to increase the surface area.
- **Heating:** Put the chopped pieces into a beaker. Pour distilled water into it to submerge the material properly. Now, boil the mixture at 100°C for 20 to 30 minutes.
- **Decantation:** Carefully pour off the excess water from the beaker.
- **Mechanical Extraction:** Transfer the softened tissue into a blender or a standard mortar and pestle, slightly in a heterogenous.

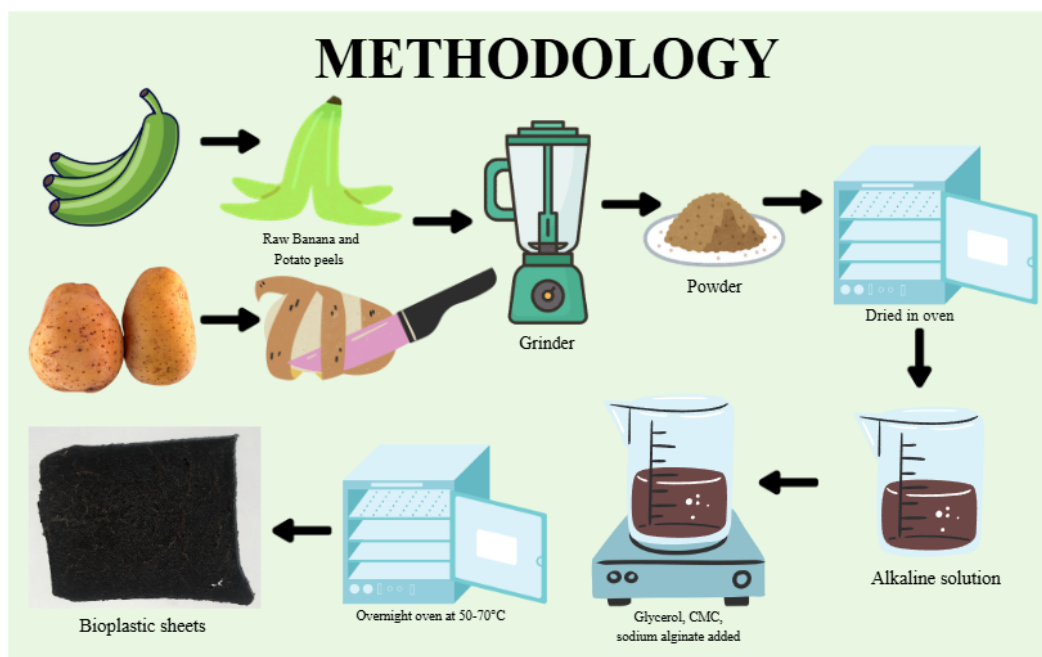


Figure 3.6: Illustrates the methodology of the synthesis of bioplastic from *Solanum tuberosum* and *Musa paradisiaca* peel.

### Steps:

1. Take of banana peels and potato peels in 2 separate beakers.
2. Boil these beakers of distilled water for around 30 minutes, until they completely soften, then decant the water.
3. Then use a laboratory blender or mortar and a pestle to grind or soften the peels into a completely smoothen uniform paste.
3. Weigh the 15gm of Green banana peels paste and 5gm of Potato peel paste in a beaker and mix them . Add 1.8 mL of HCL to the it. Stir thoroughly with glass rod for one to two minutes this acid disrupt the branches in structures. Then wash it with water 2-3 times.
4. Add 1.2 mL of glycerol and 1.8 mL of Carboxymethyl cellulose (CMC) or Sodium Alginate to the mixture stir vigorously until the mixture looks completely homogeneous.
5. Then check the PH and if required, set it at 7.0 with NaOH, and then wash the mixture with distilled water.
6. Place the beaker on a hot plate heat the mixture roughly from 85 to 95 degree while stirring constantly watch the texture change it will transform from brainy paste into thick, uniform semi-translucent glue-like mixture this is usually take 10 to 15 minutes.
7. While the mixture is still hot, pour it into a nonstick surface like a glass Petri dish. Use the spatula to spread as thin as evenly possible then dry it in a laboratory at 55°C for about four to six hour completely until it becomes solid.
8. Remove the biofilm from the nonstick surface at room temperature (RT).

### **3.5 Preliminary screenings**

These quick baseline checks evaluate the quality of the biofilm .

- Visual inspection and texture scan is done by holding the dried film up to a light source check the uniformity, bubbles or cracks. It should also feel flexible and smooth.
- Thickness is consistently checked by digital micrometre or capillary to measure the thickness of film across different points and then check the average to ensure the uniform.

## CHAPTER 4

### Results and discussion



Figure 4.1 Bioplastic synthesised from powder of Green banana peels and Potato Peel

#### 4.1 Morphology and Physical Properties

In this research, At the end an Opaque, dark-coloured biofilm matrix. The dark colour of this matrix is due to the presence of the enzymatic browning products like polyphenols and tannins that are native to the epicarp of the raw *Musa paradisiaca* (Alcivar-Gavilanes et al., 2022) and *Solanum tuberosum*.

The unbleached biofilm matrix carrying highly uniform structural integrity, slight textured surface, and high macroscopic continuity. The Prime reason leading to such properties is bioplastic matrix is the structural integration of the bio-based binders with the CMC, which inhibit the phase separation between the hydrophobic constituents banana fibres, and hydrophilic parts of potato starches.

They provided microstructural advantages where the banana peel cellulose fibrils contributed toward the reinforcing network and the potato starch served as the continuous filling matrix (Kumar & Nair, 2023).

## 4.2 Chemical Structure Verification (FTIR Analysis)

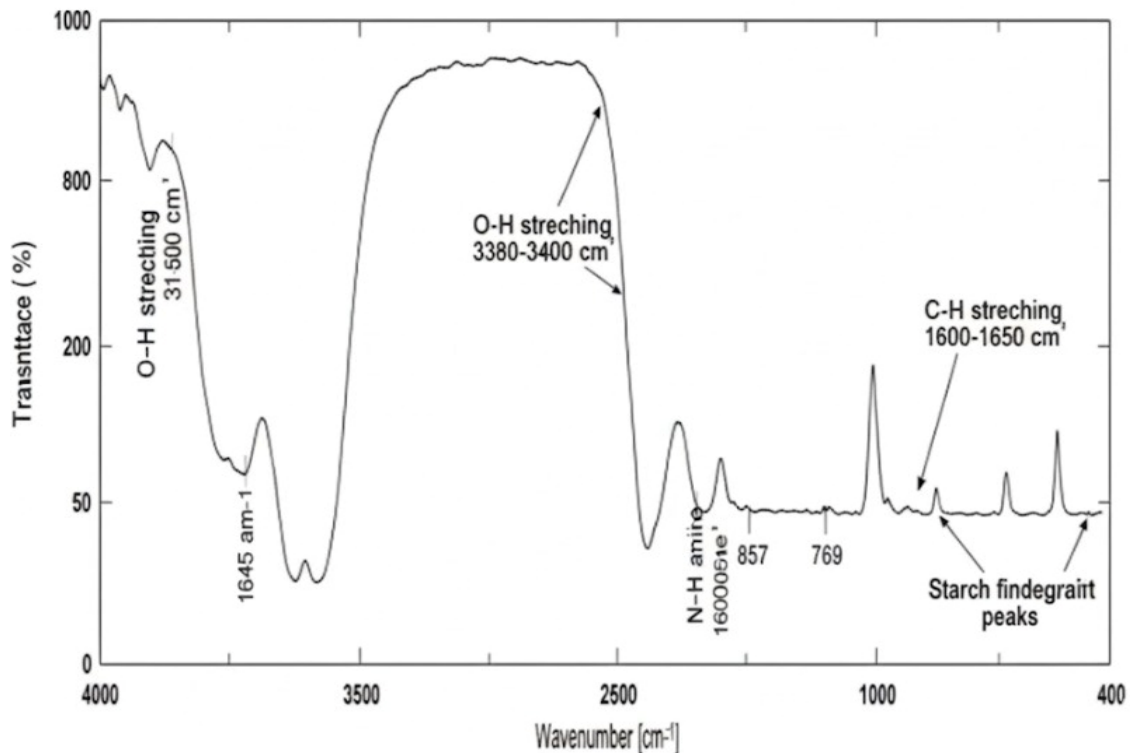


Figure 4.2 FTIR analysis of bioplastic sheet obtained from combination of 75% Raw Banana peels and 25% Potato Peels

Molecular interaction, degree of cross-linking, and functionality of the composite network (my research) are determined by Fourier-Transform Infrared Spectroscopy (FTIR). Which revealed successful blending and no phase segregation between the components, thus leading to the development of an effective hybrid structure (my research). The wide and high-intensity band appearing at the  $3200 \text{ cm}^{-1}$  to  $3450 \text{ cm}^{-1}$  range depicts the presence of -OH stretching vibrations. The results also show a strong hydrogen bonding between the potato starch amylose chain, banana cellulose, glycerol, and the CMC binder network (Rani, 2026; my research). A clear peak detected at  $2920 \text{ cm}^{-1}$  suggests that there were C-H stretching vibrations, which are indicative of the aliphatic chains of the plasticizer and carbohydrates (Shafqat et al., 2021). Additionally, the intense peaks observed at the range of  $1600 \text{ cm}^{-1}$  and  $1650 \text{ cm}^{-1}$  can be attributed to the carbonyl (C=O) stretching vibrations from the carboxylate groups of the CMC and sodium alginate binder components (my research). The efficiency of alkaline digestion method involving Sodium hydroxide (NaOH) was efficient in breaking is Proved by significant C-O-C ether linkage stretching vibration at the fingerprint region of  $1000 \text{ cm}^{-1}$  and  $1150 \text{ cm}^{-1}$

## 4.3 Mechanical Properties

The mechanical properties of the biofilm is depend greatly on the ratio and composition of the industrial waste materials used. If only unmodified potato starch are taken, then films usually shows a high tensile strength, which can easily break due to brittleness and low elongation strain (Jinnah et al., 2022). On the other hand, the raw biofilm made of banana peels

solely, shows high flexibility but insufficient stiffness and mechanical resistance (Al-Qadri, 2025).

The mechanical synergy between these components in the developed biofilm is quite significant as Banana peels have played an important role in eliminating its brittle fracture as opposed to solely tuber are films are used in making the material, it will be more flexible and capable of elongation. Whereas, the role of potato peels are contributed toward increasing the tensile strength and rigidity of the film, enabling it to withstand a greater mechanical stress. So to get appropriate results it is important to make optimal ratio of amylose and amylopectin in the potato-based material (Rani, 2026), as well as the high aspect ratio of the cellulose microfibrils obtained from banana peels (Sultan & Johari, 2021). Additionally, the use of Carboxymethyl cellulose (CMC) as a binding agent resulted in creating a network of that cross-links that make the polymer stress bearable.

#### 4.4 Environmental and Barrier Resistances

**Thermal Resistance:** The biofilm spread is allowed to Continuous oven-drying at around 50°C to 70°C temperature allowed for constant drying throughout, ensuring the absence of localized heating and thus thermal warping or structural cracking of the resulting films. The obtained unbleached bioplastic shows thermal resistance. Enhanced thermal resistance results from the formation of strong hydrogen bonds between cellulose and starch chains, thus necessitating greater thermal energy to disrupt the polymers' matrix (Othman et al., 2021). When a flame test is also performed, the bioplastic material is converted into ash.



Figure 4.2 Flame Test

#### 4.5 Water Resistance

Naturally, Starch-based materials owing to high amounts of hydroxyl groups in their chemical composition. So they are highly water-soluble and have high moisture absorption properties (Shafqat et al., 2021). To make the bioplastic resistant to water in this study. The steps were followed:

Firstly, pre-treatment with sodium hydroxide made cellulose fractions more crystallised, decreasing the number of potential binding sites to water.

Secondly, bio-based binders like CMC make dense surface layers, which serve as a barrier to moisture vapour permeance.

4.6 Resistance to Microorganisms and Decomposition: The resulting biofilm is resisted to microbial decomposition when used by having strong microbial resistance in standard storage conditions, while being totally degradable when buried in the soil. Pure potato peel starch, however, decomposed quickly if kept inside the soil, resulting in losses of more than 85% within very brief spans because of rapid enzymatic decomposition via amylase activity (Al-Qadri, 2025); the appropriate addition of banana lignocellulose fibers helped in increasing the shelf life of the product. The high density and unbleached nature of the polymeric compound also play a vital role in preventing early microbial growth (Kakadellis & Harris, 2020; my research).

#### **4.7 Sustainability Framework and Relevance to Industry**

The utilization of chips industry generated, *Solanum tuberosum* and *Musa paradisiaca* peel waste in the production of extremely resilient bioplastic materials. It aligns with the concepts of the circular bioeconomy of the zero-carbon footprint framework (Vatieri, 2025). Using peels of *Solanum tuberosum* and *Musa paradisiaca* as the primary raw material, the process described here adheres perfectly with a "low-impact, zero-burden" system that does not create food scarcity at all nor waste agricultural land resources (Pandey, 2026; Ebrahimian et al., 2022).

From an economic perspective, the green manufacturing process provides a means for supporting Mission 2047 goals in India through nurturing such domestic innovations in material science, not just reducing waste plastic generation but also moving towards a complete elimination of petroleum-based disposable packaging (Rodriguez et al., 2024; my research).

## CHAPTER: 5

### CONCLUSION

The production of environment-friendly bioplastics through the conversion of the commercial waste of *Solanum tuberosum* and *Musa paradisiaca* into bioplastics can provide alternative materials to conventional fossil fuel-based plastics. This technology takes a step ahead in the direction from simple single biomass-based systems to complex multi-biomass-based hybrids. The preparation involves fresh banana and potato peels from chips processing waste, each having its own unique property as a base component in the mix. While potato peel has a high fraction of starch and banana peel has lignocellulose fibre that acts as the internal structure of the polymer matrix. This idea addresses two major environmental problems simultaneously. One is that the organic wastes coming from the chips industry that can be Utilize to good use and secondly, it eliminates environmental pollution created by plastic use.

With regard to practical processes, any adjustments in the chemical aspect are key to making up for the problems associated with the inherent physical properties of the biopolymers. Starch, as one of these biopolymers, is inherently very unstable due to strong hydrogen bonding inside it. So to add mobile plasticizer is important since glycerol allows itself to be incorporated between the tightly bound molecules, thus creating a flexible film. The precise control of the thermal gelatinization and pH neutralization is essential to achieve stability, proper stretching properties, and even texture-all within the tight range of 6.8-7.3 pH values. Addition of carboxymethyl cellulose (CMC), however, serves as an effective binding agent.

Besides reinforcement, one of the major physical challenges that would require careful bench-level experimentation in order to be addressed is the material's inherent hydrophilicity. Being an organic compound, starch-based matrices contain numerous free hydroxyl groups in the chains of their molecules, which would mean an intense affinity towards moisture from the ambient air. In case this material were used in everyday items, such as footwear, coats, or automobile upholstery, rain and high humidity levels would result in swelling and destruction of the material, or complete dissolution thereof. One of the directions for further research might involve looking for ways to create sustainable hydrophobic barriers for the material. For instance, we could try coating the material with thin layers of natural and heat-resistant waxes, such as candelilla or carnauba, as well as applying plant drying oils, such as linseed. An alternative solution could include mixing the starch matrix extracted from fruit peel with other biodegradable copolymers, such as Polylactic Acid (PLA) or Polyhydroxyalkanoates (PHA).

In summary, these bioplastic products derived from waste materials contribute to the circular bioeconomy model. The process involves upcycling local skin by-products of tubers and processing by-products where the low-value food waste products are converted to high-value biomaterials. This waste recycling system will help reduce the significant levels of greenhouse gases released into the atmosphere when disposing of organic waste in landfill sites. In addition, the final product can also be converted to bio-leather, thus providing an eco-friendly solution to chromium tanned leather processes.

Lastly, transitioning this process from an experimental petri dish operation into a full-fledged, scalable continuous industrial process on the factory floor necessitates a dose of cold hard reality. It is imperative that we perform a Techno-Economic Analysis in order to establish the logistical considerations of harvesting enormous quantities of wet peel waste directly from commercial potato chip manufacturers and industry fruit processors, before these biological materials have begun to decompose. Mechanistically speaking, we must analyze how this

hydrogel reacts to being cast from the static environment of a laboratory beaker into a continuous extrusion line or knife coating apparatus in an industrial setting. In addition, conducting a comprehensive, cradle-to-grave Lifecycle Assessment will be crucial to scientifically proving that these dual-waste films reduce carbon footprints, chemical toxins, and water consumption rates dramatically compared to the synthetic PU fake leather and harmful chrome leather skins. Gaining these facts in hand via international standardization processes, such as performing ASTM D882 tensile testing for elongation measurements, ASTM D570 absorption studies, and soil burial analysis, will be necessary to provide solid engineering data to win over the international textile trade.

For developing this particular blend of banana and potato into an efficient competition with bio-leathers, it is necessary to conduct immediate secondary research on this product. In future studies, special attention should be paid to creating reinforcement for the skin-like fabric by integrating tough lignocellulosic fiber systems obtained from other agricultural waste products such as bagasse, hemp, or pineapple leaves. It will significantly enhance the resistance of the fabric to tearing since cellulose, even being provided in CMC form, gives only the basic structure of the product. Another interesting option would be considering the use of natural tannins for cross-linking, which would avoid environmental contamination with toxic metals.

## **References:**

1. Alcivar-Gavilanes, M. G., Carrillo-Anchundia, K. L., & Riera, M. A. (2022). Development of a Bioplastic from Banana Peel. *Ingeniería e Investigación*, 42(1), e92768.
2. Caliskan, A. (2025). Systematic Literature Review on the Utilization of Tuber Crop Skins in the Context of Circular Agriculture. *International Journal of Recycling of Organic Waste in Agriculture*.
3. Kakadellis, S., & Harris, Z. M. (2020). Don't throw the baby out with the bathwater: The role of biodegradable plastics in the circular economy. *Science of the Total Environment*, 705.
4. Kumar, R., & Nair, S. (2023). Multi-component biocomposites: Synergistic exploitation of mixed fruit and vegetable peel waste for green packaging. *Polymer Degradation and Stability*, 209.
5. Othman, N., et al. (2021). Thermal and physical properties of industrial potato peel waste-based bioplastic films. *Materials Today: Proceedings*, 42.
6. Pandey, K. (2026). Biodegradable Innovations: Harnessing Agriculture for Eco-Friendly Plastics. *Biodegradable Polymers and Materials*.
7. Rani, G. J. (2026). Valorization of Potato Peel Waste into Starch-Based Bioplastic Films using Glycerol and Sorbitol Plasticizers. *Current World Environment*.
8. Rodriguez, J., et al. (2024). Hybrid bioplastics from mixed food processing waste streams: A path toward eliminating single-use industrial plastics. *Journal of Environmental Management*, 352.
9. Vatteri, C. (2025). Waste to worth: bioplastic synthesis from lignocellulosic food waste in the age of the circular bioeconomy. *Frontiers in Sustainable Food Systems*.
10. Al-Qadri, F. A. (2025). Banana Peel and Potato as a Biodegradable Plastic. *Indian Journal of Science and Technology*, 18(10), 796–802.
11. Danial, A. W., Hamdy, S. M., Alrumman, S. A., Gad El-Rab, S. M. F., Shoreit, A. M. & Hesham, A. L. (2021). Bioplastic Production by *Bacillus wiedmannii* AS-02 OK576278 Using Different Agricultural Wastes. *Microorganisms*, 9(11), 2395. <https://doi.org/10.3390/microorganisms9112395>
12. Ebrahimian, F., Denayer, J., & Karimi, K. (2022). Potato peel waste biorefinery for the sustainable production of biofuels, bioplastics, and biosorbents. *Bioresource Technology*, 360, 127609.
13. Jinnah, M., et al. (2022). Mechanical and thermal characterization of potato starch-derived biodegradable packaging. *Journal of Cleaner Production*, 340, 130712.
14. Kossalbayev, B. D., et al. (2025). Biodegradable Packaging from Agricultural Wastes: A Comprehensive Review of Processing Techniques, Material Properties, and Future Prospects. *Polymers*.

15. Othman, N., et al. (2021). Thermal and physical properties of industrial potato peel waste-based bioplastic films. *Materials Today: Proceedings*, 42, 231-238.
16. Shafqat, A., Al-Zaqri, N., Tahir, A., & Alsalmeh, A. (2021). Synthesis and characterization of starch based bioplastics using varying plant-based ingredients, plasticizers and natural fillers. *Saudi Journal of Biological Sciences*, 28(3), 1739-1749. <https://doi.org/10.1016/j.sjbs.2020.12.015>
17. Sultan, N. F., & Johari, W. L. W. (2021). The potential of banana peel as an eco-friendly source for bioplastic production. *Journal of Functional Materials and Biomaterials*, 8(2), 45-56.

## msc

### ORIGINALITY REPORT

|                  |                  |              |                |
|------------------|------------------|--------------|----------------|
| <b>10%</b>       | <b>3%</b>        | <b>4%</b>    | <b>9%</b>      |
| SIMILARITY INDEX | INTERNET SOURCES | PUBLICATIONS | STUDENT PAPERS |

### PRIMARY SOURCES

|          |  |               |
|----------|--|---------------|
| <b>1</b> | <b>Submitted to Delhi Technological University</b><br>Student Paper    | <b>4%</b>     |
| <b>2</b> | <b>dspace.dtu.ac.in:8080</b><br>Internet Source                        | <b>2%</b>     |
| <b>3</b> | <b>www.dspace.dtu.ac.in:8080</b><br>Internet Source                    | <b>2%</b>     |
| <b>4</b> | <b>Submitted to Jawaharlal Nehru University (JNU)</b><br>Student Paper | <b>1%</b>     |
| <b>5</b> | <b>elibrary.tucl.edu.np</b><br>Internet Source                         | <b>&lt;1%</b> |
| <b>6</b> | <b>unsworks.unsw.edu.au</b><br>Internet Source                         | <b>&lt;1%</b> |
| <b>7</b> | <b>d-nb.info</b><br>Internet Source                                    | <b>&lt;1%</b> |

Exclude quotes

On

Exclude matches

< 14 words



**DELHI TECHNOLOGICAL UNIVERSITY**  
(Formerly Delhi College of Engineering)  
Shahbad Daulatpur, Main, Bawana Road, Delhi-42

**PLAGIARISM VERIFICATION**

Title of the Thesis “**Valorisation of *Solanum tuberosum* and *Musa paradisiaca* peel waste into Functional Bioplastic**”

Name of the Student Jyotisna

Supervisor Prof. Jai Gopal Sharma

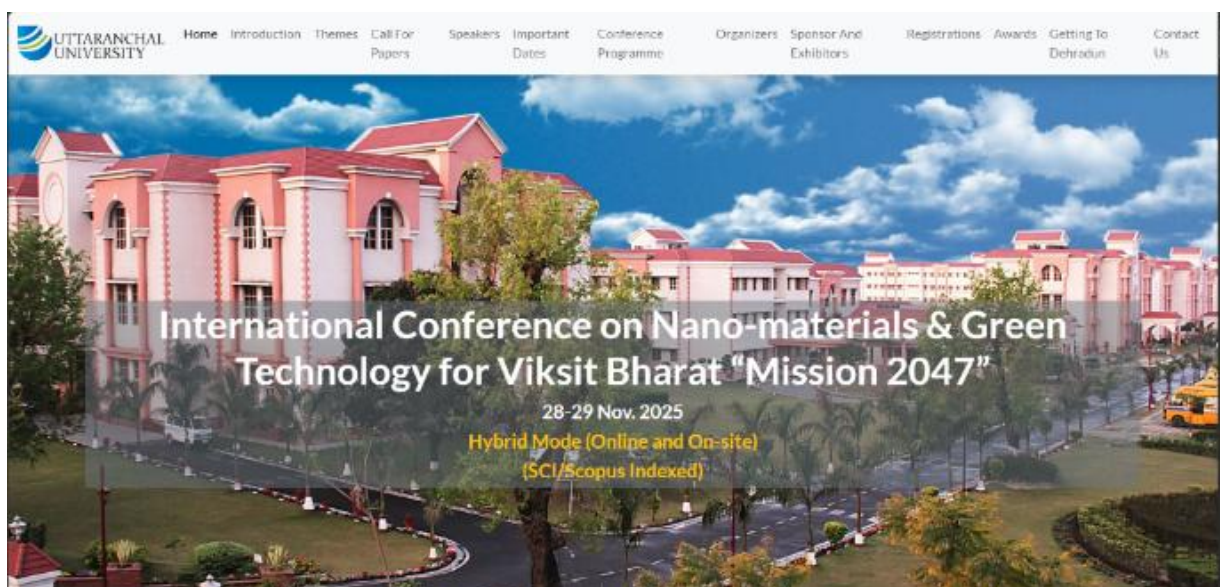
Department, Department of Biotechnology

This is to report that above thesis was scanned for similarity detection process and outcome is given below:

Software used : Turnitin Similarity index: 10%

Date: 25 May 2026

# 1) “International Conference on Nano-materials & Green Technology for Viksit Bharat Mission 2047”



## Green Conversion of Chips industry waste into bioplastic: A step toward Green Technology for Viksit Bharat.

Jyotisna, Akanksha  
Delhi Technological University, DTU  
jyotisna2004@gmail.com

### ABSTRACT

The aim of this study is to produce bioplastics from Chips industry waste, as a eco- friendly alternative to petroleum based plastics. The chips-industrial waste, banana peels, and potato peel waste generated in huge amounts. Firstly, we dried raw banana peels and potato peels, grinded them into fine powdered form, and dissolved them into an alkaline solution. And used bio-based binding agents for casting. And we dried our sheets in oven for overnight at 50-70°C. This experiment used glycerol as a plasticizer to increase its flexibility and Sodium Hydroxide (NaOH) for degrading lignin, hemicellulose, micellulose, and other complex polymers in plant biomass. Further, the results can be enhanced by adding sodium alginate along with glycerol and carboxymethyl cellulose (CMC) as a binding agent to enhance the flexibility. Bioplastics were black in color (without adding bleaching agents like H<sub>2</sub>O<sub>2</sub> or NaOCl) and showed heat resistance, water resistance and microbial growth resistance properties to a greater extent. Further the blending and nanostructure is investigated and confirmed by FTIR Spectroscopy. The study proves that a combination of Raw Banana peels, which are abundant in cellulose, hemicellulose, lignin, polyphenol and pectin leads to high flexibility and elongation. Whereas potato peels, which contain starch like amylose and amylopectin contribute to high tensile strength and elasticity. This project is support the India's Mission 2047 by promoting the waste valorization and sustainable materials development under the framework of green technology as it recycling food waste into a valuable product —biodegradable bioplastic.

MSC 00



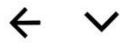
UTTARANCHAL UNIVERSITY, DEHRADUN  
Premnagar, Dehradun (Uttarakhand) INDIA-248007

www.uudoon.in

☎ : 0135-3509300,0135-2770300

|                        |  |                       |                       |
|------------------------|--|-----------------------|-----------------------|
| <b>Receipt No</b>      | : <u>M212511167</u>  | <b>Receipt Date</b>   | : 15/11/2025          |
| <b>Received From</b>   | : <u>Ms. Jyotisna/MSc. Biotechnology</u>   |                       |                       |
| <b>Amount</b>          | : 500/- <b>Amount in words . (Five Hundred Only)</b>   |                       |                       |
| <b>For Payment of</b>  | : <b>Registration Fee</b> INTERNATIONAL CONFERENCE RECEIPT International Conference on Nano-materials & Green Technology for Viksit Bharat "Mission 2047" (ICNMG-2025) |                       |                       |
| <b>Date of Event</b>   | : <u>28/11/2025</u>  | <b>To</b>             | : <u>29/11/2025</u>   |
| <b>Mode of Payment</b> | : <u>Online</u>  | <b>Transaction ID</b> | : <u>114096984665</u> |
| <b>Received By</b>     | : <u>UTTARANCHAL UNIVERSITY</u>  | <b>Date</b>           | : 15/11/2025          |

**Note:- This is system generated receipt and doesn't require any signature.**



## Event Registration Successfully Completed



Your **Event Fee** payment is done successfully. Please quote your transaction reference number for any queries.



**Name of Event :** International Conference on Nano-materials & Green Technology for Viksit Bharat "Mission 2047" (ICNMGT-2025)  
**User Name :** Jyotisna  
**University :** Delhi technological University  
**College :** Delhi technological University, Department of Biotechnology  
**Program/Designation :** MSc. Biotechnology  
**Mobile No. :** 7986357734  
**Email-ID :** jyotisna2004@gmail.com  
**Transaction ID :** Order\_8de9c54973bebf  
**Transaction Ref. No. :** 114096984665  
**Date and Time :** 15/11/2025 3:05PM  
**Amount :** Rs. 500

Print

## 2) Towards Sustainability: Innovations and Environmental Impact In Leather Manufacturing for the Textile Industry



7 ICSIE 2026 [About](#) [Speakers](#) [Program Committee](#) [Call for Papers](#) [Paper Submission](#) [Journal Publication](#) [Accepted Paper](#) [FAQ](#) [Contact](#)

# 17<sup>TH</sup> INTERNATIONAL CONFERENCE ON SCIENCE AND INNOVATIVE ENGINEERING -17 ICSIE 2026

HYBRID CONFERENCE : 26TH - 27TH APRIL 2026

ORGANISED BY

Prince Dr. K. Vasudevan College of Engineering and Technology,  
Chennai, India

Collaboration With

Manipal University College,  
Malaysia

[Register](#)

Registered papers of "ICSIE 2026" will be published in Scopus Journal, Scopus Book Chapter, Web of Science, SCI,




To ORGANISATION OF SCIENCE AND INNOV...

₹2,200

id ICSIE2601896 online presentation  
category 2

✓ Completed

16 Apr 2026, 5:59 pm

 State Bank of India 9269 ▼

UPI transaction ID  
610687047125

To: ORGANISATION OF SCIENCE AND  
INNOVATIVE ENGINEERING  
osiet@indianbk

From: Jyotisna . (State Bank of India)  
Google Pay • jyotisna2004@oksbi

Google transaction ID  
CICAgNiiiKSuaw



## **222. TOWARDS SUSTAINABILITY: INNOVATIONS AND ENVIRONMENTAL IMPACTS IN LEATHER MANUFACTURING FOR THE TEXTILE INDUSTRY**

Jyotisna , Akanksha Kushwaha, Jai Gopal Sharma  
Department of Biotechnology,  
Delhi Technological University,  
Delhi, India,

The textile industry can utilise all kinds of resources available in nature, from animals to plants and to microbes. But evolution of textile materials has intensely hampered nature as well. From very ancient times people are attracted by animal leather and fur for their aesthetics and practical qualities, but in recent years, these materials have become a subject of debate due to increasing awareness of ethical rights and concerns surrounding animal welfare and environmental impact. If we talk about eco-friendly, cruelty-free sustainable fashion then plant-based leather, waste-based leather offers stylish alternatives to traditional leather. This review article discusses about the real-world applications of scalability, cost analysis of the products. This also talks about how sustainable approach of making bio-leathers connects to carbon neutrality, SDG12, and SDG13. This article compares productivity, processing, new approaches and environmental impact related to all types of leathers. This article also deals with life cycle assessment (LCA) of leather industry.

*Prince Dr.K.Vasudevan college of Engineering and Technology, India  
Manipal University College Malaysia, Melaka, Malaysia*

*ISBN 978-81-69206-38-9*

### 3) Harnessing AI-driven Sentiment analysis to map the HCI landscape to sustainable materials. A Comparative study of animal leather vs synthetic leather perceptions



Arvind  
to me

Apr 7, 2026, 1:11PM ☆ 😊 ↶ ⋮

Dear Authors,

Thank you for your abstract submission for poster presentation, Poster ID: **HCICC-2026-Poster-106**.

The abstract is provisionally accepted for presentation in HCICC-2026. You are suggested to complete the registration process and submit the details with given link: <https://forms.gle/RQaiVz6JbdgzF4QP9>

Convener

--

Unfeigned regards,

Dr. Arvind Sharma (Postdoctoral\* | Ph.D. (CSE) | M. Tech. (CSE) | M.Sc. (CS))  
Associate Professor | PI, SU CPS Lab Co-Powered by TIF (AWaDH), IIT Ropar  
Yogananda School of Artificial Intelligence, Computers and Data-Sciences  
Shoolini University, Kumarhatti, District - Solan, Himachal Pradesh (173229)  
Official Email: [arvind@shooliniuniversity.com](mailto:arvind@shooliniuniversity.com)  
Personal Email: [sharmaarvind0786@hotmail.com](mailto:sharmaarvind0786@hotmail.com), [sharmaarvind00786@gmail.com](mailto:sharmaarvind00786@gmail.com)  
<https://www.linkedin.com/in/dr-arvind-k-sharma-b749941aa>  
<https://shooliniuniversity.com>

↶ Reply   ↷ Forward   😊



[Home](#) [About](#) [Organising Committee](#) [Register Here](#) [Contact Us](#) [Previous Conferences](#) ▾

#### Important Dates

- Paper Submission Due: February 28, 2026
- Decision: March 1, 2026 (onwards)
- Final/Camera-Ready Submission Due: May 20, 2026
- Registration (Open): March 1, 2026
- Registration (Close): June 10, 2026
- Conference Dates: June 22-23, 2026

#### Conference Includes

- Invited talks
- Paper and Poster presentations
- Workshops
- Start-up Exhibitions

#### Publication Partner

All the accepted then presented paper will be considered for Publication with:

- Edited Volume of Elsevier from Advances in Ubiquitous Sensing Applications for Healthcare series. (SCOPUS Indexed)
- Edited Volume of CRC Press, Taylor & Francis Group (SCOPUS Indexed, Indexing is subject to Quality of Content)

#### Call for Papers

HCICC - 2026 will provide an excellent international forum for sharing knowledge and experimental results in theory, methodology and applications of human computer interaction (HCI) and cognitive science. The aim of the conference is to provide a platform for researchers & practitioners from both academia as well as industry to meet and distribute knowledge of cutting-edge technologies. Authors are solicited to contribute to the conference by submitting their original, unpublished, research work, which is not currently under review by any other conference/journal as per the tracks given below (but not limited too). The EasyChair service was used for managing the submissions and peer-reviewing process for this conference.

Programme Tracks



₹6,500.00

Paid to  
SHOOLINI UNIVERSITY OF BIO  
TECHNOLOGY AND MANAGEMENT  
SCIENCES  
UPI ID: jyotisna2004@oksbi  
20 April 2026, 01:45pm



