# DEVELOPMENT AND EVALUATION OF BIODEGRADABLE PLASTIC USING BANANA PEEL STARCH

**By**


**PEEYUSH KUMAR MEENA (2016-06-015)**

**RAJU PRAJAPATI (2016-06-017)**

**SHREYASH SHEREKAR (2016-06-022)**

***Department of Food and Agricultural Process Engineering***

**KELAPPAJI COLLEGE OF AGRICULTURAL ENGINEERING & TECHNOLOGY**

**KERALA AGRICULTURAL UNIVERSITY**

**TAVANUR, MALAPPURAM - 679 573**

**KERALA, INDIA**


**2020**

# DEVELOPMENT AND EVALUATION OF BIODEGRADABLE PLASTIC USING BANANA PEEL STARCH

**By**

**PEEYUSH KUMAR MEENA (2016-06-015)**

**RAJU PRAJAPATI (2016-06-017)**

**SHREYASH SHEREKAR (2016-06-022)**

## PROJECT REPORT

**Submitted in partial fulfillment of the requirement for the degree of**

**BACHELOR OF TECHNOLOGY**

**IN**

**FOOD ENGINEERING**

**Faculty of Agricultural Engineering and Technology**

**Kerala Agricultural University**

**Department of Processing and Food Engineering**
**Kelappaji College of Agricultural Engineering & Technology**
**Tavanur, Malappuram - 679 573, Kerala, India**
**2020**

## *DECLARATION*

We hereby declare that this thesis entitled "DEVELOPMENT AND EVALUATION OF BIODEGRADABLE PLASTIC USING BANANA PEEL STARCH" is a bonafide record of research work done by us during the course of academic programme in the Kerala Agricultural University and the thesis has not previously formed the basis for the award of any degree, diploma, associateship, fellowship or other similar title, of any other University or Society.

**PEEYUSH KUMAR MEENA (2016-06-015)**

**RAJU PRAJAPATI (2016-06-017)**

**SHREYASH SHEREKAR (2016-06-022)**

Tavanur
Date: 16-02-2020

## *CERTIFICATE*

Certified that this project report entitled "**DEVELOPMENT AND EVALUATION OF BIODEGRADABLE PLASTIC USING BANANA PEEL STARCH"** is a record of project work done jointly by Mr. Peeyush kumar meena, Mr. Raju prajapati, Mr. Shreyash sherekar, under my guidance and supervision and that it has not previously formed the basis for any degree, diploma, fellowship or associateship or other similar title of another University or Society.


**Mrs. Sreeja R.**
Assistant Professor
Dept. of Processing and Food Engineering
Kelappaji College of Agricultural Engineering and Technology
Kerala Agricultural University

**Claudia K L**
Assistant Professor (contract)
Department of Processing & Food Engineering
KCAET Tavanur


Tavanur
Date:

## *ACKNOWLEDGEMENT*

Any accomplishment requires the efforts of many people and this work is no different. We find great pleasure in expressing our deep sense of gratitude towards all those who have made it possible for us to complete this project with success.

First of all we would like to express our true and sincere gratitude to our mentor **Mrs. Sreeja R,** Assistant Professor, Dept. of Processing and Food Engineering, Kelappaji College of Agricultural Engineering and Technology, Tavanur for her dynamic and valuable guidance, care, patience and keen interest in our project work. This project has been a result of combined efforts of our guide and us. She has been a strong and reassuring support to us throughout this project. We consider it as our greatest fortune to have her as the guide for our project work and our obligation to her lasts forever.

With deep sense of gratitude and due respect, we express our heartfelt thanks to **Dr. Sathyan K K**, Dean (Agri. Engg), KCAET, Tavanur, for the support that he offered while carrying out the project work.

We engrave our deep sense of gratitude to **Er. Claudia K L**, Department of Processing and Food Engineering, K.C.A.E.T, Tavanur.

We express our profound sense of gratitude to **Mrs. Jojitha**, **Mrs Geetha**, staff members of Department of Processing and Food Engineering, K.C.A.E.T, Tavanur and **Mr. Radhakrishnan M.V.**, Lab Assistant for their immense help.

We express our thanks to all the **staff members of library**, K.C.A.E.T, Tavanur for their ever willing help and cooperation. We express our sincere thanks and gratitude to **Kerala Agricultural University** for providing this opportunity to do the project work.

We are greatly indebted to our **parents** for their love, blessings, and support which gave strength to complete the study. We also acknowledge our **friends** for their support and care throughout the project duration.

Last but not the least, we bow our heads before **God Almighty** for the blessings bestowed upon us which made us to materialize this endeavour.

**PEEYUSH KUMAR MEENA**

**RAJU PRAJAPATI**

**SHREYASH SHEREKAR**

***DEDICATED TO ALL FOOD ENGINEERS***

***CONTENTS***

## *LIST OF TABLES*

## *LIST OF FIGURES*

*LIST OF PLATES*

## *LIST OF GRAPHS*

## *SYMBOLS AND ABBREVIATIONS*

| | | |
|---|---|---|
| *et al.* | : | And others |
| % | : | Per cent |
| & | : | And |
| / | : | Per |
| < | : | Less than |
| ± | : | Plus or minus sign |
| Ø | : | Angle of repose |
| ° | : | Degree |
| °C | : | Degree centigrade |
| Φ | : | Sphericity |
| ρ | : | True density |
| $\rho_b$ | : | Bulk density |
| µ | : | Coefficient of friction |
| a* | : | Greenness or redness |
| B | : | Breadth |
| b* | : | Blueness or yellowness |
| cm | : | Centimetre |
| db | : | Dry basis |
| etc | : | Etcetera |
| F | : | Frictional force |
| Fig. | : | Figure |
| g | : | Gram |
| g/100g | : | Gram per 100 gram |

| | | |
|---|---|---|
| H | : | Height |
| h | : | Hour |
| ha | : | Hectares |
| hp | : | Horse power |
| kg | : | Kilogram |
| $kg/m^3$ | : | Kilogram per meter cube |
| Kwh | : | Kilo watt hour |
| L | : | Length |
| L* | : | Lightness or darkness |
| Ltd. | : | Limited |
| $M_b$ | : | Mass of cocoa bean |
| m/s | : | Meter per second |
| Mha | : | Million hectares |
| min | : | Minute |
| ml | : | Milliliter |
| mm | : | Millimeter |
| mm/s | : | Millimeter per second |
| N | : | Newton |
| No. | : | Number |
| P | : | Combination |
| pH | : | Percentage of H+ ions |
| rpm | : | Revolution per minute |
| s | : | Second |
| T | : | Thickness |

| | | |
|---|---|---|
| t | : | Temperature |
| t/ha | : | Tonnes by hectares |
| V | : | Volts |
| $V_b$ | : | Volume of cocoa bean |
| *Viz* | : | Namely |
| W | : | Watts |
| wb | : | Wet basis |
| $W_i$ | : | Intial weight of bean |
| $W_d$ | : | Dry weight of bean |
| w/w | : | Weight by weight |
| AOAC | : | Association of official analytical chemists |
| APEDA | : | Agricultural Products Export Development Authority |
| BD | : | Bulk density |
| FFA | : | Free Fatty Acid |
| GI | : | Galvanised Iron |
| HACCP | : | Hazard Analysis Critical Control Point |
| IOCCC | : | International Office of Cocoa, Chocolate Sugar Confectionery |
| KCAET | : | Kelappaji College of Agricultural Engineering and Technology |
| LTD | : | Limited |
| MT | : | Metric Tonnes |
| MMT | : | Million Metric Tonnes |
| PAH | : | Polycyclic Aromatic Hydrocarbons |
| PVT | : | Private |

| | | |
|---|---|---|
| SD | : | Standard Deviation |
| SS | : | Stainless Steel |
| TV | : | Total volume |

# ***INTRODUCTION***

# CHAPTER 1

# INTRODUCTION

Today's plastics are designed with little consideration for their ultimate disposability or recyclability. This has resulted in mounting worldwide concerns over the environmental consequences of such materials when they enter the waste stream after their intended uses, a particular concern are polymers used in single use, disposable plastic applications. Plastics are strong, light-weight, inexpensive, easily processable and energy efficient. They have excellent barrier properties. They are disposable, and very durable. However, these attributes of strength and indestructibility that cause problems when these materials enter the waste stream. They are not readily broken down by the natural elements in the environment or in waste management infrastructures such as composting to become a part of the biological carbon cycle of our ecosystem. This results in an irreversible build-up of these materials in the environment causing scaring of landscapes, fouling of beaches, and posing a serious hazard to marine life. Plastics are resistant to biological degradation because microorganisms do not have enzymes capable of degrading and utilizing most manmade polymers. In addition, the hydrophobic character of plastics inhibits enzyme activity and the low surface area of plastics with their inherent high molecular weight further compounds the problem.

Biodegradable plastics are a new generation of polymers emerging on the world market. Biodegradable plastics have an expanding range of potential applications, and driven by the growing use of plastics in packaging and the perception that biodegradable plastics are 'environmentally friendly'; their use is predicted to increase. However, issues are also emerging regarding the use of biodegradable plastics and their potential impacts on the environment and effects on established recycling systems and technologies. The banana fruit's peel was selected for this experiment because it is a waste material rich of starch-according to Songklanakarin Journal of Science and Technology, the proximate composition of a banana peel is shown Table 1.1.

# Table 1.1 Banana peel composition

| Item | Composition (g/100 g dry matter) |
|---|---|
| Protein | 8.6±0.1 |
| Fat | 13.1±0.2 |
| Starch | 12.78±0.9 |
| Ash | 15.25±0.1 |
| Total Dietary Fat | 50.25±0.2 |

(According to The Packaging Bulletin Magazine's January issue)It is a proven fact that starch and cellulose are important raw materials used in the biodegradable plastic industry (Packaging Bulletin, 2009). Since they are rich with starch and this starch is very easy to extract, potatoes are the most commonly used raw materials. For this experiment use different type of material that is banana peel because it also rich with starch. Actually, banana peel has no scientific name because only living organisms could have it. Banana could have the scientific name of common banana that is Musaceae musa.

The propane-1, 2, 3-triol used in the experiment functions as a plasticizer, an additive used to develop or improve the plasticity of a material. It disconnects the polymer chains from one another; restraining them from becoming rows of chains and acquiring a crystalline structure. The formation of the crystalline structure is undesired because it is a brittle and fragile structure which makes the plastic brittle and fragile as well. Instead of the crystalline structure, the formation of film (not becoming rows of chains of polymers) is desired. (Baru debtra etal.,2019)

Starch consists of two different types of polymer chains, called amylose and amylopectin, made up of adjoined glucose molecules. Amylose is a chain of D-glucose unit that is connected together by a-1,-4 bonds, the amylopectin contains short chains of a-1,-4 linked D-glucose units that are branched by a-1,-6 bonds. Although starch is a biodegradable polymer that can be manufactured in large quantities at relatively low cost, handled easily and form film products with low oxygen permeability, the major challenge with native starch is that, it is brittle and hydrophilic. These limit its various applications such as its use for the manufacturing of plastic bags and food packaging. To enhance its flexibility and improve the easiness for processing or plasticizing starch, various plasticizers (glycerol, glycol, sorbitol) are employed to convert the starch into thermoplastic starch (TPS) via the application of heat and shear over extrusion processes. The hydrochloric acid is used in the hydrolysis of amylopectin, which is needed in order to aid the process of film formation due to the H-bonding amongst the chains of glucose in starch, since amylopectin restricts the film formation. The sodium hydroxide used in the experiment is simply used in order to neutralize the pH of the medium. (Baru debtra etal.,2019)

# *REVIEW OF LITERATURE*

# CHAPTER 2

# REVIEW OF LITERATURE

The Royal Society of Chemistry describes the generic process for the manufacture of starch based bioplastics. This involves hydrolysis of the starch by using an acid. Abdorreza *et al* (2011) have described in their paper the physiological, thermal and rheological properties of acid hydrolyzed starch. This paper shows that the amylose content increases initially but continuous hydrolysis causes a decrease in the amylose content. This fact is also corroborated in the paper by Karntarat Wuttisela *et al* (2008). The amylose content is responsible for the plastic formation in starch. Plasticizers are used to impart flexibility and mouldability to the bio- plastic samples. Thawien Bourtoom, of the Prince of Songkla University, Thailand, in his paper(2007) discusses the effects of the common types of plasticizers used and their effects on various properties like tensile strength, elongation at break and water vapour permeability of the bioplastic film.

Applications of bio-plastics, especially in the packaging industry have been discussed in the paper by Nanou Peelman *et al* (2013) where bio-based polymers used as a component in (food) packaging materials is considered, different strategies for improving barrier properties of bio-based packaging and permeability values and mechanical properties of multi-layered biobased plastics is also discussed.

The present research work with emphasis on synthesis of bio plastic material by using fruit waste mainly banana peel. The polymer produced using the banana peel blended with the glycerol could help in the formation of plastic having the characteristic features of pliability, user friendliness and strength.

# 2.1. PLASTICS

## 2.1.1 History

A plastic is a type of synthetic or man-made polymer; similar in many ways to natural resins found in trees and other plants. Webster's Dictionary defines plastics as: any of various complex organic compounds produced by polymerization, capable of being moulded, extruded, cast into various shapes and films, or drawn into filaments and then used as textile fibers.

The development of artificial plastics or polymers started around 1860, when John Wesley Hyatt developed a cellulose derivative. His product was later patented under the name Celluloid and was quite successful commercially, being used in the manufacture of products ranging from dental plates to men’s collars.

Over the next few decades, more and more plastics were introduced, including some modified natural polymers like rayon, made from cellulose products. Shortly after the turn of the century, Leo Hendrik Baekeland, a Belgian-American chemist, developed the first completely synthetic plastic which he sold under the name Bakelite.

In 1920, a major breakthrough occurred in the development of plastic materials. A German chemist, Hermann Staudinger, hypothesized that plastics were made up of very large molecules held together by strong chemical bonds. This spurred an increase in research in the field of plastics. Many new plastic products were designed during the 1920s and 1930s, including nylon, methyl methacrylate, also known as Lucite or Plexiglas, and polytetrafluoroethylene, which was marketed as Teflon in 1950.

Nylon was first prepared by Wallace H. Carothers of DuPont, but was set aside as having no useful characteristics, because in its initial form, nylon was a sticky material with little structural integrity. Later on, Julian Hill, a chemist at DuPont, observed that, when drawn out, nylon threads were quite strong and had a silky appearance and then realized that they could be useful as a fibre.

### 2.1.2 CLASSIFICATION STRUCTURE AND USAGE

Plastics are essentially a by-product of petroleum refining. In plastics production, the components of oil or natural gas are heated in a cracking process, yielding hydrocarbon monomers that are then chemically bonded into polymers. Different combinations of monomers produce polymers with different characteristics.

The basic backbone of a hydrocarbon polymer is a chain of carbon atoms, with hydrogen atoms branching off the carbon spine. Some plastics contain other elements as well. For example, Teflon contains fluorine, PVC contains chlorine, and nylon contains nitrogen.

Plastics have vast applications in all walks of life. They are used from manufacturing of packaging items, furniture, and fabrics to medical equipment and construction articles. There are various reasons for the popularity of plastics. Some of them are

Low cost

Resistance to chemical solar and microbial degradation

Thermal and chemically insulating properties

Low weight

### 2.1.3 Thermosets Plastic

1. Solidifies or sets irreversibly when heated.
2. The molecules of these plastics are cross linked in three dimensions and this is why they cannot be reshaped or recycled.
3. They are useful for their durability and strength.
4. Used primarily in automobiles and construction applications. Other uses are adhesives, inks,

   and coatings.

#### 2.1.4 Thermoplastics

1. Softens when exposed to heat and returns to original condition at room temperature.
2. Do not undergo significant chemical change.
3. Weak bond, which becomes even more weak on reheating.
4. Thermoplastics can easily be shaped and molded into products such as milk jugs, floor coverings, credit cards, and carpet fiber.

### 2.2 Problems associated with plastics

Despite their many uses and desirable properties, petroleum based conventional plastics have many disadvantages. The major reasons for looking at alternatives to plastics are because of the following drawbacks:

#### 2.2.1. Production Problems

Plastics are derivatives of petroleum, natural gas or similar substances. They are transformed into a polymer resin, which is then shaped and formed into whatever object is desired. However, as a petroleum by-product, plastics contribute to oil dependency, and in the present times it is generally recognized that oil will not be available indefinitely. This points to a possible raw material crisis in the future.

#### 2.2.2 Plastics recyclability

Although many types of plastics could potentially be recycled, very little plastic actually enters the recycling production process. The most commonly recycled type of plastic is polyethylene terephthalate (PET), which is used for soft drink bottles. Approximately 15 to 27 percent of PET bottles are recycled annually. The other type of plastic which is somewhat commonly recycled is high-density polyethylene (HDPE), which is used for shampoo bottles, milk jugs and two thirds of what are called rigid plastic containers. Approximately 10 percent of HDPE plastic is recycled annually.

These figures show that most of the plastics manufactured do not get recycled and as production continues unabated, this poses a serious problem.

### 2.2.2 Landfill disposal

The vast majority of plastics, especially plastic bags, wind up in landfills. The fact that available landfill space is becoming increasingly scarce and plastics are non biodegradable poses special problems for landfills.

Compounding the issue is the survey (*Zero Waste America. (1988-2008))* which found that 82 percent of the surveyed landfill cells had leaks, while 41 percent had a leak larger than 1 square foot). Also these leaks are detectable only if they reach landfill monitoring wells. Both old and new landfills are usually located near large bodies of water, making detection of leaks and their cleanup difficult. All these issues point to the fact that landfill disposal of plastics is not a sustainable solution.

### 2.2.3 . Incineration

Some industry officials have promoted the incineration of plastic as a means of disposal. A similar process of pyrolysis breaks plastics into a hydrocarbon soup which can be reused in oil and chemical refineries. However, both incineration and pyrolysis are more expensive than recycling, more energy intensive and also pose severe air pollution problems. In 2007, the EPA acknowledged that despite recent tightening of emission standards for waste incineration power plants, the waste-to-energy process still “create significant emissions, including trace amounts of hazardous air pollutants”.

Incinerators are a major source of 210 different dioxin compounds, plus mercury, cadmium, nitrous oxide, hydrogen chloride, sulphuric acid, fluorides, and particulate matter small enough to lodge permanently in the lungs. *( U.S. Environmental Protection Agency. (2007, December 28). Air Emissions)*

### 2.2.5. Adverse effect on Biodiversity

Plastic debris affects wildlife, human health, and the environment. Plastic pollution has directly or indirectly caused injuries and deaths in 267 species of animals (including invertebrate groups) that scientists have documented. These problems are because of various reasons which include poisoning due to consumption of plastics, suffocation due to entanglement in plastic nets etc.

The millions of tons of plastic bottles, bags, and garbage in the world's oceans are breaking down and leaching toxins posing a threat to marine life and humans. Some marine species, such as sea turtles, have been found to contain large proportions of plastics in their stomach. When this occurs, the animal typically starves, because the plastic blocks the animal's digestive tract. In some cases small bits of plastics are accidently consumed by animals. Any such animal, if eaten by another will cause the plastics to travel up the food chain. This may cause serious health hazards in a wide array of creature.

### 2.2.6. The Carbon Cycle

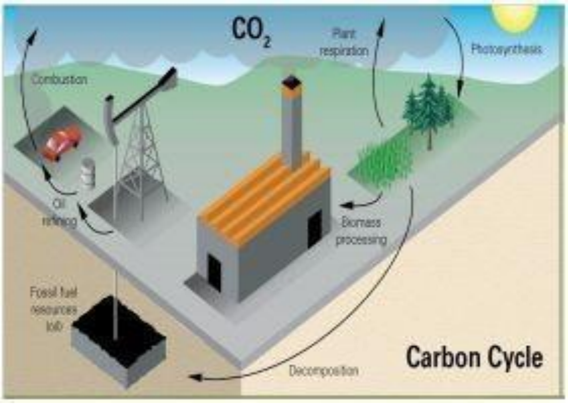



**FIGURE 2.1 CARBON CYCLE**

When a plant grows, it takes in carbon dioxide, and when it biodegrades, it releases the carbon dioxide back into the earth – it's a closed loop cycle. When we extract fossil fuels from the earth, we disrupt the natural cycle, and release carbon dioxide into the atmosphere faster than natural processes can take it away. As a result, the atmosphere is getting overloaded with carbon dioxide. Additionally, fossil fuels take millions of years to form, and are therefore non-renewable resources. In other words, we are using our fossil resources faster than they can be replaced. When we make products like plastics from fossil fuels, we are contributing to the imbalance in the environment while depleting valuable fossil resources, thereby increasing the carbon 15 footprint of the product. Bioplastics, on the other hand, can replace nearly 100% of the fossil fuel content found in conventional plastics, and require considerably less energy for production.

### 2.2.7 Tree protectors and Plant supports/stakes:

Bioplastics are being developed as an answer to forest litter, providing a guard that enables young trees to get the best possible start. Protection from vermin and hostile environment is assured early in the growing cycle but the material will bio-disintegrate as the tree passes into maturity. Unsightly litter is removed and collection costs on managed woodland eliminated.

Horticulturalists now choose bioplastics to make functional plant holders that are strong, water resistant, in a choice of colours and have the ability to decompose naturally into biomass.

## 2.3. BIOPLASTICS

Plastics that are made from renewable resources (plants like corn, tapioca, potatoes, sugar and algae) and which are fully or partially bio-based, and/or biodegradable or compostable are called bioplastics. European Bioplastics has mentioned 2 broad categories of bioplastics:

**Bio based Plastics**: The term bio based means that the material or product is (partly) derived from biomass (plants). Biomass used for bioplastics stems from plants like corn, sugarcane, or cellulose.

**Biodegradable Plastics**: these are plastics which disintegrate into organic matter and gases like CO2, etc in a particular time and compost which are specified in standard references (ISO 17088, EN 13432 / 14995 or ASTM 6400 or 6868).

However , it should be noted that the property of biodegradation does not depend on the resource basis of a material, but is rather linked to its chemical structure. In other words, 100 percent bio based plastics may be non-biodegradable, and 100 percent fossil based plastics can biodegrade. The figure below explains the broad categories into which bio plastics are divided

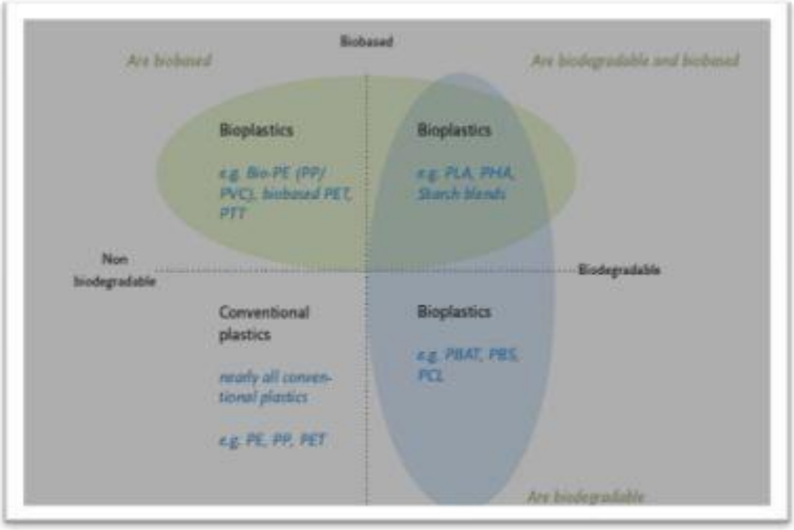



**FIGURE 2.2 BIOPLASTICS**

Thus all the highlighted regions in the graph represent bioplastics. They can thus be bio based-biodegradable, non bio based-biodegradable and bio based-non biodegradable.

## 2.4. ECONOMIC SCENARIO

Bioplastics are used in an increasing number of markets – from packaging, catering products, consumer electronics, automotive, agriculture/horticulture and toys to textiles and a number of other segments.

The world currently utilises approximately 260 million tonnes of plastics each year. Bioplastics make up about 0.1% of the global market.

### 2.4.1 Market Size

Growing demand for more sustainable solutions is reflected in growing production capacities of bioplastics: in 2011 production capacities amounted to approximately 1.2 million tonnes. Market data of “European Bioplastics” forecasts the increase in the production capacities by fivefold by 2016 – to roughly 6 million tonnes.

The factors driving market development are both internal and external. External factors make bioplastics the attractive choice. This is reflected in the high rate of consumer acceptance. Moreover, the extensively publicised effects of climate change, price increases of fossil materials, and the increasing dependence on fossil resources also contribute to bioplastics being viewed favourably.

### 2.4.2 Cost

With the exception of cellulose, most bioplastic technology is relatively new and currently not cost competitive with (petro plastics). Bioplastics do not reach the fossil fuel parity on fossil fuel derived energy for their manufacturing, reducing cost advantage over petroleum-based plastic.

Forecast market growth is predicted to be greatest in non-biodegradable bioplastics. Bioplastics could also be used in more sophisticated applications such as medicine delivery systems and chemical microencapsulation. They may also replace petrochemical-based adhesives and polymer coatings. However, the plastics market is complex, highly refined and manufacturers are very selective with regard to the specific functionality and cost of plastic resins. For bioplastics to make market grounds they will need to be more cost competitive and provide functional properties that manufacturers require.

## 2.5 USAGE

Bioplastics are used in a wide variety of fields. Some of them are:

**i. Packaging**

Today, biopackaging can be found in many European supermarkets. Sainsbury in the UK may be cited as a pioneer – who first recognised the opportunities for compostable plastics packaging. Many Supermarket chains such as Delhaize (Belgium), Iper (belonging to the Carrefour group; Italy), Albert Heijn (Netherlands) and Migros (Switzerland) are actively placing their trust in biopackaging. Last year, the world`s largest retailer, Wal-Mart, introduced its first range of products in corn-based PLA packaging throughout the USA.

For supermarkets, it is also an enormous advantage to be able to compost unsold perished food products cheaply together with their packaging rather than have to separate the contents from the packaging at considerable cost. Food residues do not interfere in the slightest with this recycling. The same applies to compostable service packs, such as trays, plates, cups or cutlery.

**ii. ii. Bags**

Concerns over litter, the perceived waste of a single use item and the management of bio-waste have made this one of the fastest growing sectors for bioplastics in the early 21st century. Bioplastics form excellent replacements to conventional oil based materials in this sector with great performance characteristics, strength, good contact clarity and proven high speed production.

**iii. Wraps**

Bioplastics can be converted into waterproof and fat resistant film for a wide variety of wrapping and packing eco-options. A great natural feel and appropriate barrier technology allows products like cheese to breathe on the path to the consumer. Flexible materials with paper-like dead-fold characteristics broaden the application range. The inherent property of biodegradability offers specific advantages in agriculture and horticulture.

**iv. Mulch film**

Bioplastics can be converted into fully opaque or semi-transparent films that provide the ideal growing environment yet can be ploughed into the ground at the end of the growth cycle, providing soil nutrition for future seasons. Producing pure foods with a minimum of pesticide use is a powerful sales argument in vegetable-growing or organic farming. Ploughing in mulching films after use instead of collecting them from the field, cleaning off the soil and returning them for recycling, is practical and improves the economics of the operation.

**2.6 Personal Care and Hygiene**

Most personal care items like toothbrushes, razors etc can be manufactured from bioplastics. Matt finishing of the bioplastics ensures that the plastic razor has good grip and gives a smooth shave. The material surface characteristics ensure good grip performance whilst providing a device that will withstand every day use. Testing for products in this sector has demonstrated suitable thermal, moisture and fatigue performance.

Meanwhile bioplastics can be blown to form opaque, soft-feel bottles for the likes of shampoos and creams. Complementing bioplastic caps can be injection or compression moulded. These products are one time use and throw products, if bioplastics can be used here, it can solve the problems of plastic as a gross waste to a largest extent.

**2.7 Electronics**

In 2009, Japanese multinational, NEC has successfully developed and implemented a flame-retardant bio-plastic that can be used in electronic devices due to its high flame retardancy and processability. The new bioplastic includes more than 75% biomass components, and can be produced using manufacturing and moulding processes that halve the CO2 emissions of conventional processes used to make petroleum-based flame-retardant plastics (PC/ABS plastics). NEC's new bioplastic is therefore one of the most environmentally friendly flame retardant plastics used for casing of electronic devices in the world.

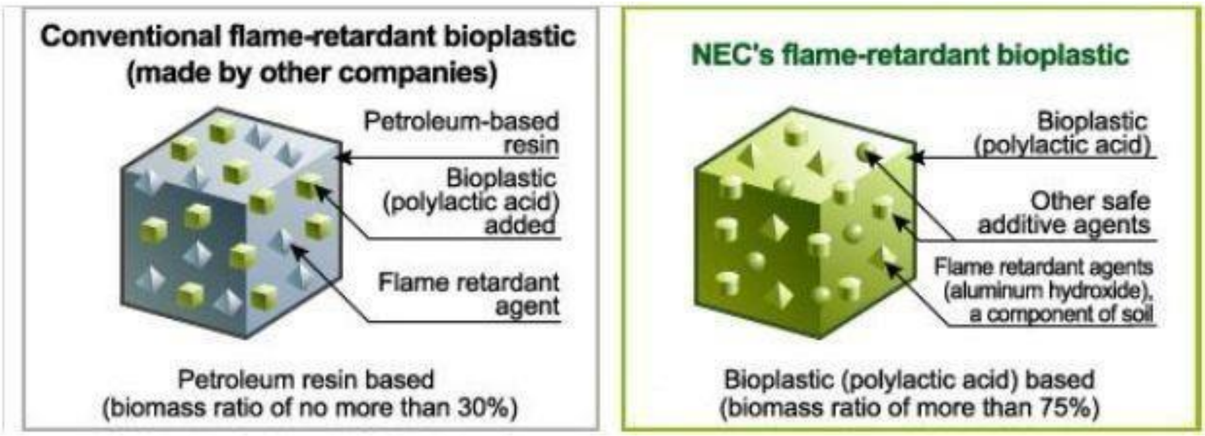



**FIGURE 2.3 COMPARISION BETWEEN CONVENTIONAL & NEC'S FLAME RETARDENT BIO PLASTIC**

In another case, Mitsubishi Plastics, Inc has already succeeded in raising the heat-resistance and strength of polylactic acid by combining it with other biodegradable plasticsand filler, and the result was used to make the plastic casing of a new version of Sony Corp.'s Walkman. Mitsubishi Plastics had previously looked at bioplastic as something that would mainly be used in the manufacture of casings and wrappings, but the company now feels confident that this revolutionary material has entered a new phase in its development in which more complex applications will be found.

### 2.7.1 Automobiles

Ford Motor Corp. was the first automaker in the world to use bioplastics in the manufacture of auto parts way back in the 1920s. Recently, Toyota motor corp. employed them in the cover for 32 the spare tire in the Raum, a new model that went on sale this May. The bioplastic used here is polylactic acid (PLA) is made from plants, such as sweet potatoes and sugarcane.

### 2.7.2 Food Packing

In a new study published on June 6, 2013 in the peer-reviewed scientific journal *Trends in Food Science and Technology*, researchers from the University of Gent review the application of bioplastics in food packaging (Peelman *et al* 2013). The main bioplastics are polylactide (PLA), starch, polyhydroxyalkanoates (PHA) and cellulose. PLA is the most widely used bioplastics with application for fresh foods, dry foods such as pasta and potato chips, fruit drinks, yoghurt, and meat. Starch has been used as an alternative for polystyrene (PS) to package tomatoes and chocolate. Cellulose is used to package dry foods and fresh produce. While all of these materials are biodegradable, their functional limitations have so far restricted their widespread application in food packaging. As outlined by Peelman and colleagues, the main limitations of the four materials is their brittleness, thermal instability, low melt strength, difficult heat sealability, high vapour and oxygen permeability, poor mechanical properties, stiffness and poor impact resistance.

In their study Peelman and colleagues review three processes, which may be used to improve the properties of bioplastics, namely coating, blends and chemical/physical modifications.

**i. Coating**

Coating comprises the application of a thin bio based or non-bio based layer to the bioplastics. Such coatings can lower the oxygen and vapour permeability, increase tensile strength and result in higher elastic properties.

**ii. Blending**

Blending bioplastics is another approach to improve functionality. Cellulose and other bio based materials may be used to create improved blends. Most bioplastics are immiscible; however the introduction of functional groups, chemical modification or esterification can enhance compatibility. Blending can reduce brittleness, increasing vapour water barrier properties, flexibility, and tensile strength. .

**iii. Chemical and/or physical modification**

The third approach to improve functionality is chemical and/or physical modification. It can be used to enhance compatibility between two polymers or to improve the functional properties directly. Citric acid added to starch films improves water and vapour properties (WVP). Cross linking cellulose acetate with phosphates improves tensile strength and slows water uptake and degradation.

Epichlorohydrin-modified starch has an increased tensile strength and improved elongation. Partially substituting wheat gluten with hydrolyzed keratin or soaking wheat gluten film in CaCl2 and distilled water improves the water vapour and oxygen barrier properties of a wheat gluten derived film. Peelman and colleagues conclude that using coatings, blending and chemical/physical modification can extend the use of bioplastics in food packaging to a wide variety of food other than fresh produce and dry foods.

### 2.7.3 Construction

The Institute of Building Structures and Structural Design (ITKE) at the University of Stuttgart (Germany) has worked on fiber-reinforced polymers, bionics and the development of new building materials. Architect Carmen Köhler is investigating the applicability of natural fiber-reinforced biopolymers in the construction industry. In contrast to fiberglass-reinforced polymers, natural fiber-reinforced polymers are considerably lighter, emission stable and breathable. “Construction material that is breathable at the same time as preventing moisture from penetrating, is also of major interest in architectural terms,” said Carmen Köhler explaining that she finds the material suitable for facades and insulations. The group of researchers are currently investigating polylactide, cellulose acetate and other materials. Selection criteria are price, temperature stability and the potential use of additives during processing. “We hope that the material will be classified as B2 or even B1 class construction material,” said Köhler explaining that B1 and B2 refer to the degree of inflammability of materials, which should be as low as possible 34.

Classification:

A1 (100% non-combustible)

A2 (~98% non-combustible)

B1 difficult to ignite

B2 normal combustibility (like wood)

B3 easily ignited

The testing of the material has shown that cellulose acetate and polylactide (PLA) are very resistant to UV. The biopolymers did not become discolored to the same extent as traditional transparent polymers when exposed to sunlight. Cellulose acetate is already used for transparent heat insulation.

But there are a lot more markets starting to use bioplastic materials such as buildings and construction, household, leisure or fiber applications (clothing, upholstery).

Products that show vast growth rates include bags, catering products, mulching films or food/beverage packaging. Functional properties are often crucial in the user decision. The environmental aspect and the very high consumer acceptance are additional selling points.

## 2.8 ADVANTAGES OF BIOPLASTICS

### 2.8.1 Eco Friendly

Traditional plastics are the petroleum based plastics which depend on fossil fuels which is an unsustainable source. Also acquiring fossil fuels does a lot of harm to the natural environment. Bioplastics on the other hand are made from bio mass like trees, vegetables, even waste which is completely bio degradable. So bioplastics are made from completely renewable source. Even during the manufacturing of plastics, a lot of pollution occurs, for example, during production, PVC plants can release dioxins, known carcinogens that bio-accumulate in humans and wildlife and are associated with reproductive and immune system disorders

### 2.8.2 Require less time to degrade

Traditional plastics take thousands of years to degrade, these plastics lie in the environment, most notably on the ocean floor where they do the maximum damage for years. These plastics hamper the growth and kill the natural habitats.

Bioplastics on the other hand, require considerably less time to biodegrade. This degradation can be carried out at home for some bioplastics and even for the bioplastics which require specific conditions, time required to degrade completely is considerably less. This reduces the huge pressure on our existing landfills.

### 2.8.3 Toxicity

Some of the plastics degrade rapidly in the oceans releasing very harmful chemicals into the sea, thus harming the animals, plants and also harming the humans by entering the food chain. Biodegradable plastics are completely safe and do not have any chemicals or toxins. This plastic harmlessly breaks down and gets absorbed into the earth. Such advantages of bioplastics are of extreme importance, as the toxic plastic load on the earth is growing and at this rate will cause a whole range of problems for future generations.

### 2.8.4 Lower energy consumption

Companies still use fossil fuels for the manufacture of bioplastics; however, many bioplastics use considerably less fuel for their manufacture.

### 2.8.5 Environmental protection

Burning fossil resources increases the share of CO2 in atmosphere, which causes an increase of the average temperature (greenhouse effect). Scientists see a distinct connection between CO2 increase in atmosphere and the increase of number of thunderstorms, floods and aridity. Climate protection is nowadays a central part of environmental policy, due to the fact that climate change can create far-reaching negative consequences. Governments and organizations work against this threat with targeted measures.

## 2.9 CHALLENGES FOR BIOPLASTICS

### 2.9.1 Misconceptions

Even though bio degradable plastics are considered to be good for the environment, they can harm the nature in certain ways. Emission of Greenhouse gases like methane and carbon dioxide, while they are degrading, is very large at landfill sites. This can be handled by designing plastics so that they degrade slowly or by collecting the methane released and use it elsewhere as fuel.

Some bioplastics need specific conditions to bio degrade, these conditions may not be available at all the landfills or consumers may not have access to landfills, in such case it becomes important to design bioplastics which are bio degradable in a normal soil compost.

### 2.9.2 Environmental Impact

Starch based bioplastics are produced generally from plants like corn, potatoes and so on. This puts massive pressure on the agricultural crops as they have to cater the need of ever growing population. To make plastics, crops have to be grown and this could lead to deforestation.

Bioplastics are generally produced from crops like corn, potatoes, and soybeans. These crops are often genetically modified to improve their resistance to diseases, pests, insects etc. and increase their yield. This practice however carries a very high risk to the environment as such crops can be toxic for humans as well as for animals.

### 2.9.3 Cost

Bioplastics are a newer technology and require still more research and development to get established. Bioplastics are not thus, comparable to plastics with respect to cost.

# *MATERIAL AND METHODS*

# CHAPTER 3

# MATERIALS & METHODS

Methodology consist of extraction of starch from banana peel, production of developing the biodegradable plastic, biodegradation test of the biodegradable plastic and elongation experiment of biodegradable plastic.

**3.1 Raw material:** Raw banana (Nendran) procured from the nearby market.

**3.2 Chemicals and Reagents**: The chemicals and reagents used for biodegradable plastic film include: Acetic acid, Glycerol ,Sodium hydroxide (NaOH) and sorbitol .

**3.3 Equipments**

1. **Microwave oven**: IFB 20BC5 microwave oven which can work at 220℃ and it has a control panel by which can control time and temperature according to the requirements.


**PLATE 3.1 MICROWAVE OVEN**

2. **Filter paper and muslin cloth**: Filter paper is a semi-permeable paper barrier placed perpendicular to a liquid or air flow. It is used to separate fine solids from liquids or air. For laboratory use filter papers are made in variety of ways since specific applications require specific types of papers. The raw materials might be acid washed wooden fiber, carbon or quartz fibers.
3. **Beaker**

4. **Measuring cylinder**
5. **Pipette**
6. **Conical flask**
7. **Filter paper and muslin cloth**: Filter paper is a semi-permeable paper barrier placed perpendicular to a liquid or air flow. It is used to separate fine solids from liquids or air. For laboratory use filter papers are made in variety of ways since specific applications require specific types of papers. The raw materials might be acid washed wooden fiber, carbon or quartz fibers.
8. **Beaker**
9. **Measuring cylinder**
10. **Pipette**
11. **Conical flask**

**PLATE 3.2 CABINET DRYER**

12. **Cabinet dryer**: Cabinet dryer consist of a drying chamber (cabinet) and hot air blower. It has temperature control unit by which we can set the require temperature, heat transfer will take place by conduction.

13. **Round bottom flask**
14. **Weighing balance**
15. **Petri dish**
16. **Burette**

17. **Mixer**

18. **Micro meter :** Digital micrometers are able to take extremely accurate measurements; most can measure to 0.0005 inches and 0.001mm. At any time, the user can convert their readings from one system to the other by pressing the "mm /inch" or "unit" button.

## 3.4 SAMPLE PREPARATION

### 3.4.1 Extraction of starch from banana peel

The peels of the bananas were removed using a stainless steel knife and cut into small sizes. The banana peels were dipped in 0.5% $Na_2S_2O_5$ solution prior to the boiling processes. An 800ml beaker was filled with distilled water and placed on a Bunsen burner. The banana peels were placed in the beaker and were boiled for 30 minutes. After the boiling process, the beaker was removed from the Bunsen burner and the peels were decanted off the water and placed on and covered with a dry gauze pad, left to dry for 30 minutes. Using a hand blender, the peels were pureed until a fluid paste was formed. The fluid paste was filtered to produce banana peel starch.

### 3.4.2 Production of developing the biodegradable plastic

The amount of 25ml of banana peel starch was measured and placed in 500ml beaker. After that 3ml of acetic acid was added and the mixture was mixed using a glass stirring rod. And then 2ml of propan-1, 2, 3-triol was added to beaker. The mixture was stirred again. The mixture was poured into a petri-dish and put in the oven at 110°C. It was baked for half an hour.

## 3.5 QUALITATIVE ANALYSIS

### 3.5.1 Biodegradation test of the biodegradable plastic:

The biodegradable film was cut into 2.5cm x 2.5cm. Then, the film was buried in 5cm depth. At regular time interval, water will be sprinkled. About two days times interval, the specimens from the soil was taken and washed with distilled water. After that, the specimens was dried and the weight taken.

### 3.5.2 Elongation experiment of biodegradable plastic:

The biodegradable plastic was cut. The initial length of the biodegradable plastic was measured and recorded. The biodegradable plastic was stretched until it higher than initial length. The length of plastic was measured again and recorded.

### 3.5.1 GSM test

GSM provides the weight per unit area or the weight per unit length or "weight per running yard" in lament terms. Before performing a standard GSM test, you must acquire samples using a GSM Cutter. The GSM Round Cutter is a tool used in extracting precision-cut samples of 100 square centimetres. The GSM cutter is a sleek, rounded metal device with a knob fitted in the centre. At the bottom, blades of the cutter cleanly cut dishes of sample to be placed on the testing scale. Normally, 10 fabric disks are cut as samples for weighing.

**PLATE 3.3 WEIGHING BALANCE**

### 3.5.2 Bursting test

Bursting Strength of the materials is a major property that defines the strength and quality of the packaging products. This property of the packaging helps to measure the strength and quality of the materials and helps to determine the suitability of the material for different applications. To perform the bursting test with the testing machine, we took circular shape of our sample according to the size of the diaphragm of the instrument. Now place the device on the rubber diaphragm and apply sufficient amount of pressure gradually on the sample until the sample burst. . The sensor on the instrument will measure the amount of force which is required to burst the sample.


**PLATE 3.4 BURSTING STRENGTH TESTER**

The maximum force which is sensed by the machine is considered as the maximum bursting strength that a material can bear to its maximum. This also helps the manufacturers to decide the factor of safety for the materials that are packed inside and helps to measure the suitability of the material for the required application.

### 3.5.1 Cobb's test:

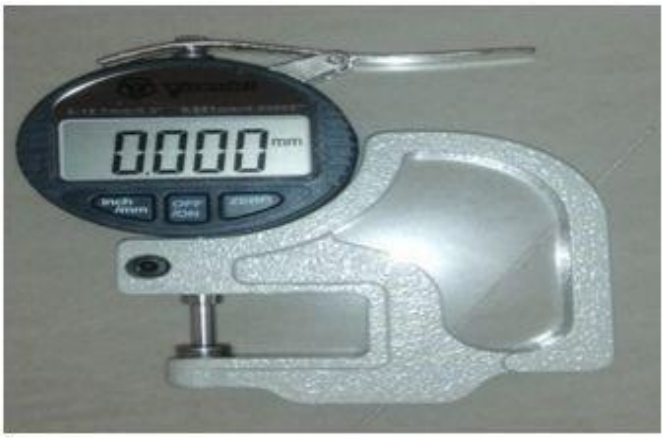

**PLATE. 3.5 COBB TESTER**

Cobb Sizing Tester determines the amount of water absorbed by the paper, cardboard, corrugated fiber board, paperboard, in a specified time under standardized conditions. Various characteristics of paper such as sizing, porosity, etc. are evaluated by the water absorptiveness.

Took a piece of sample of a banana peel plastic and cut in circular shape more than the diameter of the rubber Weight the sample using digital weighing balance. Now Place the sample between cylinder and rubber pad and support. Tighten sample manually with the screw. Ensure sample has no crush while clamping and then invert the cylinder back to its position.
When the sample is clamped, add 100 or 250 ml water up to the marking in the cylinder as required for the test. Start the stop water for 1 to 10 minutes for single to multilayered board Remove water from the cylinder when the test completes and takes out the sample. Drain excessive amount of water with the help of hand roller by moving one time forward and one time backward. Weight the sample again with digital weighing machine To determine the Cobb Value, subtract the weight of the sample before testing from the weight of the sample after testing.

### 3.5.1 Thickness test:

Measure the thickness of film by the use of micrometer. It uses screw to transform small distance into large rotations of the screw that are big enough to read from a scale.




## PLATE 3.6 DIGITAL MICROMETER

# *RESULTS AND DISCUSSION*

# CHAPTER 4

# RESULT AND DISCUSSION

The success of bioplastic from banana peels is based on the fact that it is rich in starch. The films were prepared successfully by the mixing and casting method. A brown coloured elastic material with tensile strength similar to a paper (when manually pulled) was produced using banana peels. The bioplastic formed was comparatively fragile. The composite produced from banana peels was thin, papery and showed good tensile strength. Thickness of the composites ranged approximately between 0.195-0.200m (±0.4 std. error).

The composites were found to be thermo labile (heat-sensitive) as most of them turned black n burnt when heated. Almost all the composites were found to be insoluble in water, but a slight discolouration was observed in sample (banana peel treated with Na2S2O5 + potato starch) with hot and cold water treatments. When the samples were treated with acids (0.1N H2SO4, and 0.1N HCl), the composites turned to a lighter shade of brown as compared to the controls and became moist. However they were insoluble in acids. Treatment with 0.1N NaOH showed uniform results for almost all the samples, as they turned into dark brown, softer materials with partial or no solubility in alkali.

Bursting strength of approximately 55 psi (0.196mm thick)were observed for banana peels treated with $Na_2S_2O_5$.The bioplastics with lesser tensile strength and load could be useful in suture preparation in medical field and those with higher strengths could be used to replace the polythene bags. The manufacture of bioplastic from food waste is most desirable as it is a low-cost and high-value usable product. Adding other materials / chemicals to food wastes during processing enhanced the mechanical properties of the bioplastic. All the materials produced were water-soluble, hence, coating with oil or adding non toxic chemicals is suggested to favour water-proofing ability. As per similar reports tensile properties of the modified starches as compared to the native starch based materials were found to be improved. (Supriya Nandlal etal.,2017)

Biodegradable plastics made from food wastes offer wide applications in various fields. Plant-based bioplastic products can be used to assist the body's natural ability to regenerate healthy cells during healing also include bandages, sutures, and gingival patches. Additionally, because some wounds and incisions take longer to heal than others, biodegradable sutures can be constructed to degrade according to a specific time-frame for a specific level of healing.

Biodegradable staples, plastic pins, tacks, and screws are used to hold shattered bones together while they heal, to reattach ligaments, and for delicate reconstructive surgery on ankles, knees, and hands. Biodegradable dental implants, made of porous polymer particles, are being used to quickly fill the hole after a tooth has been extracted.

In this project, the experiment conducted in order to form biodegradable plastic from banana peel. The plastic was formed after several experiments were made. The plastic sample produced may not be achieving the ideal characteristic of a plastic but it is good in biodegradability as it can be composted in just 6 days. (Supriya Nandlal etal.,2017)

Of course no experiment is perfect and there is always room for improvement the experiments were not all done at . For example, the same time and the bananas used were not purchased on the same day is a limitation which could be improved by conducting all the experiments at the same time, on the same batch of banana peels. All measurements were made as precisely as possible, however while balancing there was a measurement error of ±0.2 M. (Baru debtra etal.,2017)

## 4.1 QUALITATIVE ANALYSIS

After constructing the prototype and performing the test plan a lot of times, promising results showed that the prototype successfully achieved the design requirements that were selected before which are: cost, by using cheap and available materials, production, by using alternative and renewable resource, and efficiency by using specific chemicals in order to obtain the longest shelf-life for the plastic. The material used in manufacturing the bio-plastic, banana peels, was chosen because it is one of the fruits that are very rich in starch ($C6H10O5$), which consists of two different types of polymer chains, called amylose and amylopectin, made up of adjoined glucose molecules that are bonded together forming the plastic. The hydrochloric acid (HCl) is used in the hydrolysis of amylopectin, which is needed in order to aid the process of film formation due to the H-bonding amongst the chains of glucose in starch, since amylopectin restricts the film formation.

The propane-1, 2, 3-triol (Glycerol $C_3H_8O_3$) used in the manufacturing functions as a plasticizer, an additive used to develop or improve the plasticity of a material. It disconnects the polymer chains from one another; restraining them from becoming rows of chains and acquiring a crystalline structure. The formation of the crystalline structure is undesired because it is a brittle and fragile structure which makes the plastic brittle and fragile as well. Instead of the crystalline structure, the formation of film (not becoming rows of chains of polymers) is desired.

The plastic started to decay after only 3 days of production, so in order to overcome this problem, sodium metabisulfite which its formula is ($Na_2S_2O_5$) , also known as E223, was used as it is a common material used as a food preservative with dried foods, and it succeeded in improving the shelf-life of the plastics.

### 4.1.1. MECHANICAL PROPERTIES TEST

#### 4.1.1.1Bursting strength

A biodegradable composite film must withstand the normal stress encountered during its application as a packaging material. The bursting strength indicates its resistance to rupturing, defined as the hydrostatic pressure needed to burst a paperboard sample when it is applied uniformly across its side. The average value of bursting strength was recorded as 55 psi for all the repetitions.

Bursting strength is a function of various processes performed in the biodegradable plastic making process. The increased use of fillers decreases bursting strength, while the increased use of longer fibers and surface sizing increases a paper's bursting strength.

There was observed to be no significant difference in bursting strength with the change in thickness albeit a slightly positive correlation was noted. The grammage of the product also have same relationship as the thickness. The bursting strength value increased as the amount of starch increased. The bursting strength values were increased due to the decreased of banana peel starch crystallinity in the banana peel starch films.

Moreover, the introduction of plasticizer (glycerol) into the films also resulted in higher bursting strength values as these decrease the intermolecular attractive force, improving the films flexibility and extensibility.

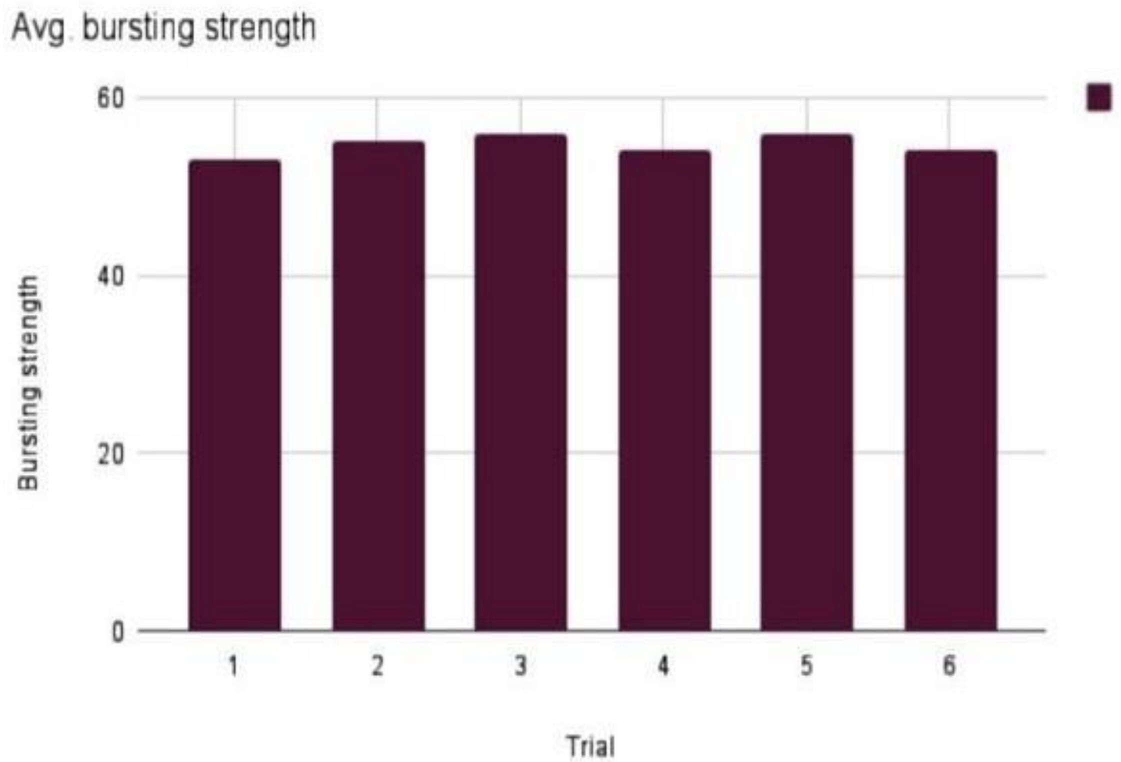



**FIG 4.1 AVERAGE BURSTING STRENGTH**

#### 4.1.1.2 Thickness

Thickness of a plastic film is very important data as it decides almost every possible physical property. The method for determining film thickness used was a micrometer, and this method is described in D6988 of the ASTM. Micrometers are relatively inexpensive, and the concept behind them appears simple, but measuring plastic film creates a number of issues. With thicker films, many of these issues are not as big of a problem, but with thinner films, micrometers present some serious limitations.

One of the most serious problems is the precision and bias of the reading. Since plastic films are often under 1 mil (25 microns) thick, and a good micrometer has a precision of +/- 0.05 mils, the micrometer in many cases is only precise to +/- 5% of the material thickness. The precision gets worse on a percentage basis as a film gets thinner, and films under 1 mil thick are fairly common.

The average thickness recorded for the trials was 0.196mm. The readings were taken on different parts of the film on the same film to avoid the locality of the data and the experiment was repeated for other trials also.

By the standard literature, the barrier properties like gas permeability, water retention and water transfer rate is known to be in accordance with the thickness when the material compared is chemically identical.

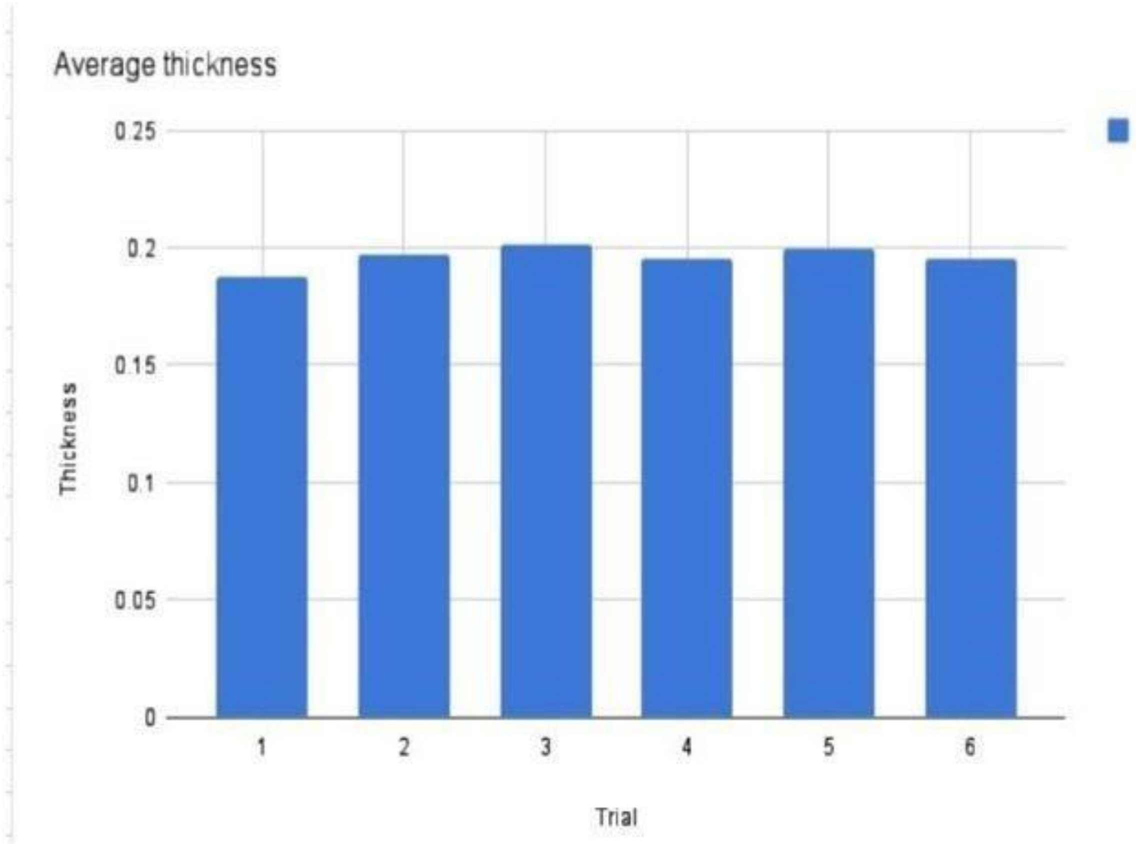



**FIG 4.2 AVERAGE THICKNESS**

#### 4.1.1.3 Colour and biodegradability

Due to the waste management requirements applicable, waste should be avoided wherever possible Unavoidable wastes must be reused wherever possible, or recycled. Wastes are used in biological waste recovery plants for the production of composts and bio-energy sources are also deemed to be recycling. Therefore, a broad range of recovery options exists for bioplastics.

However, legal requirement limits the biological recovery of bioplastics-based wastes through composting and fermentation to those products which prove to be biologically recoverable in extensive, standardised tests (e.g. EN 13432).

Among other things, the biodegradability must be verified in separate tests for all relevant organic constituents. Additives (dyes, processing aids, etc.) present in trace quantities only do not have to be tested separately. However, as these can affect the biodegradability tests, it is advisable to clarify the possible effects of additives beforehand in the form of preliminary tests, before a material runs through full certification testing.

In the experiment, no additional colouring additives were used. The colour of the biodegradable plastics was recorded to be dark brown.

**Plate 4.3 Biodegradable plastic**

As reports suggests, a rapid degradation occurred for films occur in the initial 6 days, followed by 100% composting within expected 90days. As conclusion the films produced from banana peels had potential application to be used as food packaging because it can enhance the food quality and at the same time can protect the environment.

#### 4.1.1.4 Grammage

GSM Value is the unit to measure the weight of the paper. It stands for Grams per Square Meter. It is a very simple test to perform and tells a lot about the basic properties of Paper material which is very important to decide the quality. Other than Paper, It is also used for calculating the weight of, corrugated fiber board, foils etc. For instance, the heavier a corrugated fiber board is, the better is the quality of the box made from it. The average value of grammage was recorded as 204gsm

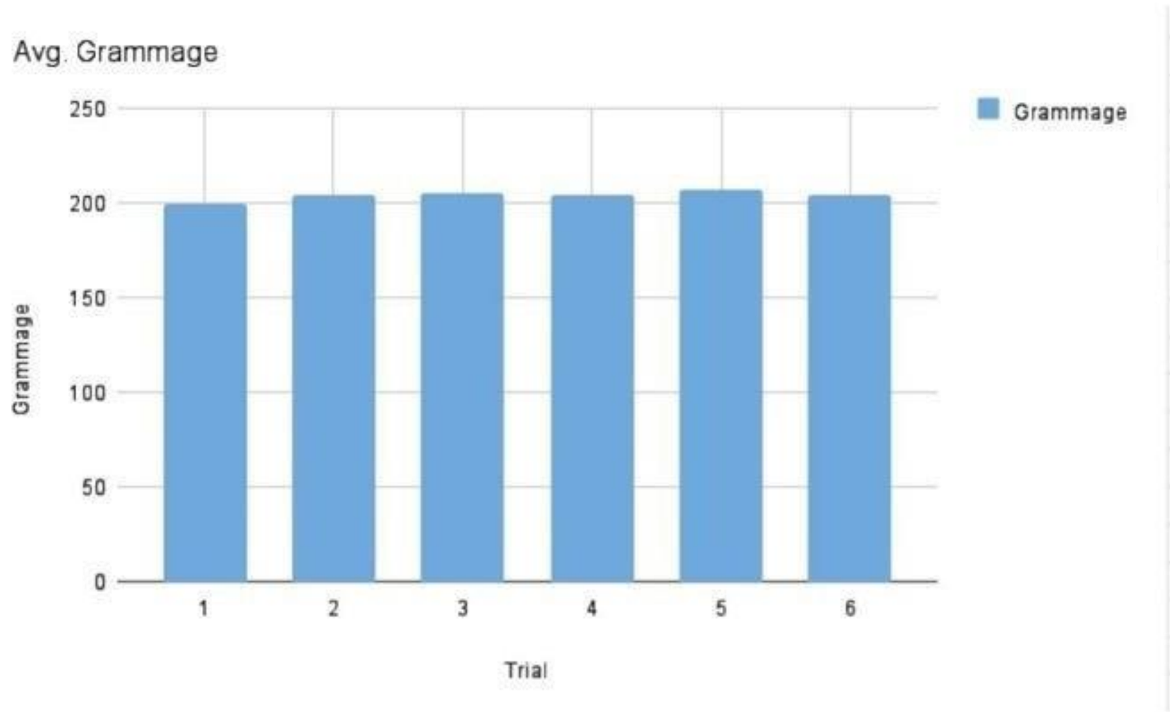



**FIG 4.4 AVERAGE GRAMMAGE**

#### 4.1.1.5 Smell

The smell which is associated with the biodegradable plastic made by this method is the characteristics to the smell of acetic acid. Acetic acid is a mono carboxylic acid because it contains only one "COOH" group. It has a sour taste and pungent smell. It is the main component of vinegar. Vinegar is typically 3-7% solution of acetic acid in water. This is because there is no neutralisation of the acetic acid which is done by the sodium hydroxide.

# *SUMMARY AND CONCLUSION*

# CHAPTER 5

# SUMMARY & CONCLUSION

Every project starts with the process of selection of raw material. The raw material selected was the raw banana peels which were obtained from the nearby shop. The material was not selected as ripened banana because when it was used the product did not satisfy the requirement. Hence, the raw banana peels are recommended for the experiment.

The peels were separated from the banana and cut into small uniform sized parts. The standard solution of 0.5%sodium metabisulphate was prepared by adding 0.95 gram into 100 ml of distilled water. The volume of the sodium metabisulphate was decided according to the availability of raw banana peels. The peels were soaked in the solution of Sodium metabisulphate for half an hour. When strained from the solution, the peels were ready for further heat treatment.

The peels were then boiled in distilled water for 0.5 hour by gas burner. The boiled peels were then strained off of water and then subjected to partial drying in a cabinet dryer at a temperature of 60℃ for 0.5 hour. This will remove the extra water which may increase the time in the process of The peels were ground by small home mixer grinder to a fine paste. The fine paste then kept for one night and excess water drained off.

The amount of 25ml of banana peel starch was measured and placed in 500ml beaker. After that 3ml of acetic acid was added and the mixture was mixed using a glass stirring rod. And then 2ml of Glycerol was added to beaker. The mixture was stirred again. The mixture was poured into a petri dish and put in the oven at 110°C. It was baked for half an hour and we got the biodegradable banana plastic film

## 5.1 FUTURE ASPECTS

Due to the myriad of data available on the subject, the project work may feel simple. There were some practical problems faced by the students which is discussed below, also we would like to share our thoughts on the future aspects for anyone performing this experiment in the future.

The first problem which was faced by the students was the smell of acetic acid, which can affect the acceptability of the product. This can be remedied by adding a strong alkali solution. The other problem which may be encountered is the spreading of the banana paste. The paste has adhesive properties so it is very difficult to spread it just after grinding. Here, we would like to suggest some little bit of cooking, which will effectively reduce the water present in the paste while also reducing the adhesive property. Care should be taken to not to remove all of the water as this may lead to charring of the product.

# *REFERENCES*

# CHAPTER 6

# REFERENCE


- Ahmed Ibrahim mohamed ahmed , Banana peerls based bio-plastics.
- Agarwal M., Koelling K., Chalmes J. 1998. Characterization of the degradation of polylatic acid.
- Barb Feldman article on Potato-based Bioplastics a Growing Field.
- Baru debtera, 2019, Synthesis and experimental study of production bio plastic from banana
- biodegradable bio plastics.
- CHEMISTRY FOR LIFE, Factors Affecting the Polymer's Properties.
- M.R. gaonkar, prashant palaskar , rishikesh navatar , 2017, Production of bioplastic by banana
- peels *proceedings of 146th THE IIER INTERNATIONAL CONFERENCE HONKONG.*
- R. mukhopadhyay, k. divya sree, Rafath saneeha, prajakta kale , umamah iram, 2017, preparation and characaterization of biodegradable plastic out of food waste as prospective and ecofriendly medical devices, *IJRASET, Volume 5 issue 12December 2017.*
- Supriya nandlal kanoujiya and Shivani kakkar khanna ,2019, Production of bioplastics from banana peels , JETIR May 2019, volume 6 ,issue 5.
- Thesis of Millan, Jemuel Paulo G. ,Bunag jose mari A. ,Cuevas , Carlo Carmelo A. , jan. 2017, Efficacy of cardava Banana ( musa paradisiaca ) as an Alternative component in making
- zamri bin yusuff.

# DEVELOPMENT AND EVALUATION OF BIODEGRADABLE PLASTIC USING BANANA PEEL STARCH

By

PEEYUSH KUMAR MEENA (2016-06-015)

RAJU PRAJAPATI (2016-06-017)

SHREYASH SHEREKAR (2016-06-022)

## ABSTRACT

**Submitted in partial fulfilment of the requirement for the degree**

**BACHELOR OF TECHNOLOGY**

**IN**

**FOOD ENGINEERING**

**Faculty of Agricultural Engineering and Technology**

**Kerala Agricultural University**

**Department of Processing and Food Engineering**

**Kelappaji College of Agricultural Engineering & Technology,**

**Tavanur, Malappuram - 679 573, Kerala, India**

**2020**

# ABSTRACT

Plastics are essentially a by-product of petroleum refining and its industry is considered one of the most essential industries because plastic, today, is practically ubiquitous right from sheets, rods, building blocks and domestic products. The extreme use of plastics can lead to damaging effects to the environment because degradation of these plastic requires more than 500 years to decompose completely, releasing toxic elements in the environment. It also affects human by destroying thyroid hormone axis or hormone levels.

Bioplastics can be defined as plastics made of biomass such as corn, banana peels and sugarcane. Biodegradability of bioplastics has been widely publicized in society and the demand for packaging is rapidly increasing among retailers and the food industry at large scale. Population growth has led to the accumulation of massive volume of non degradable waste materials across our planet. The accumulation of plastic waste has become a major concern in terms of the environment. Conventional plastics not only take many decades during decomposition, but also produce toxins while degradation. Hence, there is need to produce plastics from materials that can be readily eliminated from our biosphere in an "ecofriendly" fashion. Bioplastics are natural biopolymers synthesized and catabolized by various organisms. These get accumulated as storage materials in microbial cells under stress conditions. However, the high production cost and the availability of low-cost petrochemical derived plastics led to bioplastics being ignored for a long time. A recent global trend is to use natural, renewable, alternative resources that are beneficial in developing new materials.

Thus, the biodegradable plastic becomes the encouraging result to solve this entire problem. The objective of this study was to produce biodegradable plastic from banana peels as a substitute for the conventional plastic and to prove that the starch in the banana peel could be used in the production of the biodegradable plastic.

Select the raw banana and peels were separated from the banana and cut into small uniform sized parts by food grade knife. The standard solution of 0.5%sodium metabisulphate was prepared by adding 0.95 gram into 100 ml of distilled water. The volume of the sodium metabisulphate was

decided according to the availability of raw banana peels. The peels were soaked in the solution of Sodium metabisulphate for half an hour. When strained from the solution, the peels were ready for further heat treatment.

The peels were then boiled in distilled water for 0.5 hour by gas burner. The boiled peels were then strained off of water and then subjected to partial drying in a cabinet dryer at a temperature of 60℃ for 0.5 hour.

This will remove the extra water which may increase the time in the process of The peels were ground by small home mixer grinder to a fine paste. The fine paste then kept for one night and excess water drained off.

The amount of 25ml of banana peel starch was measured and placed in 500ml beaker. After that 3ml of acetic acid was added and the mixture was mixed using a glass stirring rod. And then 2ml of Glycerol was added to beaker. The mixture was stirred again. The mixture was poured into a petri dish and put in the oven at 110°C. It was baked for half an hour and we got the biodegradable banana plastic film.