

Production of Biodegradable Plastic from Banana Peel

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ABSTRACT: Plastic offers a variety of benefits, in a variety of shapes, such as sheets, panels, film, which can all be flexible as the application requires. Plastic is a price competitive with other materials that offer similar advantages in industrial applications, which is why it is used in a number of applications. It is light weight, strong, visually aesthetic, flexible size and shape, and cheaper price. However, use of too many plastics results in massive harmful effects. It takes longer time to degrade which is estimated about 500 years to degrade and will become toxic after decomposed. Plastic pollution can unfavourably affect lands, waterways and oceans. Humans are also affected by plastic pollution, such as through the disruption of the thyroid hormone axis or hormone levels. Thus, the biodegradable plastic becomes a promising solution to solve all this problems. The objective of this study is 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. The strength of the film was determined using the elongation test by comparing the biodegradable film with a control film and a synthetic plastic. In the soil burial degradation test, the intensity of degradation was tested for all three types of film and the biodegradable film degraded at a rapid rate compared to control film while the synthetic plastic did not degrade at all. Based on all the testing that was carried out, the biodegradable film from banana peel is the best and ideal overall compared to the control and synthetic plastic. Hence, it can be used in the industry for various applications such as molding and packaging, at the same time rescuing the environment from potential harm by synthetic plastics.

KEYWORDS: Plastic, decompose, pollution, biodegradable film, degradation test

I. INTRODUCTION

Plastic causes environmental pollution because of having non-biodegradable characteristics and they are full of harmful by-products and chemicals which are released during their break down process. It's been estimated that 400,000 barrels of oil are used each day to make plastic packaging in the world. The oil-based plastics cannot be rid easily and create landfills or environmental pollution. Bio plastics can be defined as plastics made of biomass such as banana peels and potato peels. Bio plastic is plastic made of biodegradable materials such as banana peels, fruit waste etc. They are completely safe and do not have any harmful chemicals or toxins. Bio plastics can replace petroleum-based plastics and can be made.

1.1 IDEA OF THE PROJECT

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, of 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, it is these very 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 scarring 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 Journal of Science and Technology, the proximate composition of a banana peel is shown Table

Table 1: Banana peel content

Item	Content (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 we use different type of material that is banana peel because it also rich with starch.

1.2 MATERIALS REQUIRED

Banana peel, Starch, Glycerol, HCl (Hydrochloric acid), NaOH (sodium Hydroxide), Na₂S₂O₅(Sodium Meta bisulphite), Distilled water

1.3 OBSERVATIONS

[1]Tensile strength-

The tensile strength was measured by using standard machine ASTM. In the absence of starch the tensile strength is negligible and in the presence of starch its tensile strength increases.

[2]Biodegradation-

The biodegradation period was found to be 7-9 months. After 9 month there was degradation of bio-bag due to growth of micro-organism.

1.4 ADVANTAGES AND CHALLENGES

The main advantage of bio plastics over conventional plastic is that they degrade into environment without creating any pollution. Plastic from banana peels can be used for making plastic bags and tubes due its flexibility and durability. The high production cost and the availability of low-cost petrochemical derived plastics led to bio plastics being ignored for a long time.

1.5 FUTURE SCOPE

In the future, instead of using banana peels, potato peels would be used for manufacturing the plastic and that is because this material has more starch and more polymer chains that form the plastic, so as a result it has higher efficiency than banana peels, as its efficiency is 90% while the efficiency of the banana peels is 80%. Although potato peels are available as much as banana peels, they weren't used because they require more time to dry after getting them out of the oven, as the banana peels require only 1 day, while the potato peels require at least 4 days to dry.

1.6 OBJECTIVES

- 1) Production of bioplastics from banana peels as a substitute for the conventional plastics.
- 2) To minimize pollution in the environment by the use of bioplastics.
- 3) To study and Understand Bio Degradation Process of Banana Peel.

II. REVIEW OF LITERATURE

P. Prasteen et al.The environmental crises arising from the use of petroleum based non-degradable plastics led the globe to find alternatives. Biomaterial based plastic is one such alternative. This study aimed to produce biomaterial based plastic from corn starch (Cs) and gelatin (Ge) with the addition of glycerol (Gy) and mixture of vinegar and water and to determine the effect of the amount of Gy on the properties of plastics produced using Cs and Ge separately.

M.R.GAONKAR et al. Bio plastics can be defined as plastics made of biomass such as corn, banana peels and sugarcane. Biodegradability of bio plastics has been widely publicized in society and the demand for packaging is rapidly increasing among retailers and the food industry at large scale.

Ravinder Singh et al. Banana is among the world's leading fruit crops. Banana serves as ideal food among low cost foods and serves nutrients to 4-5 billion population residing in developing country. Banana normally has a short shelf life and start deteriorating just after plucking. The quality of the bananas get further lowered during transshipment to the markets. Over and above over ripening is also a big problem. In order to overcome these problems, the processing of banana must be encouraged. Very small portion of total bananas production undergo industrial processing.

Dr Reena et al. Better management of resources to meet feedstock needs of the biofuel industry can lead to growth of the global economy. Non-edible feedstock, waste bio-material and biomass that require minimal land use should be fully exploited to sustain the biofuel industry. Our society is currently experiencing constraints imposed by our resource system, which drives industry to increase its overall efficiency by improving existing processes or finding new uses for waste. Food supply chain waste emerged as a resource with a significant potential to be employed as a raw material for the production of fuels and chemicals given the abundant volumes globally generated, its contained diversity of functionalized chemical components and the opportunity to be utilized for higher value applications.

Gaurav R. Dukare et al. When there is a choice of Smart, why to choose only Better. Environmental pollution by toxic heavy metal contamination due to rapid industrialization is a challenging problem for maintaining the quality and hygiene of water. The discharges of industrial effluents into aquatic environment cause a potential threat to the aquatic life as well as human health, which is a matter of great concern due to their toxic nature and adverse effect. Techniques used to remove heavy metal are namely physical, chemical and biological treatment.

Jayachandra Yaradoddi et al. Polyhydroxy alkanoates (PHAs) or Polyhydroxy butyrate's (PHBs) are the bio plastics, they can replace a number of traditional plastics which are currently made up of petrochemicals. The PHAs or PHBs obtained through biological origin assures the same commercial properties with the advantage of being completely natural biodegradable. Same way bio plastics prepared using the fruit waste will also serve as potential alternatives to the conventional plastic materials.

Noor Fatimah Kader Sultan et al. The aim of this study is to develop bio plastic film from a combination of two biopolymers of same source, namely banana peel and corn starch. Five banana peel films (BP film) were prepared with different concentrations of corn starch (1% up to 5%) as co-biopolymer and film without corn starch acted as a control. The films were carried out with several durability tests and characterization analyses. Based on the results obtained, the BP film with 4% corn starch gave the highest tensile strength 34.72 N/m² compared to other samples.

Manasi Ghamande et al. Bio plastics can be defined as plastics made of biomass such as banana peels and potato peels. Bio plastic is plastic made of biodegradable materials such as banana peels, fruit waste etc. The research work on synthesis of bio plastic material by using banana peels. Bio plastic prepared using the banana peels serve as potential alternative to the conventional plastic material. Making bio plastic from banana peels instead of traditional petroleum based plastic is believed to be successful solution to increase efficiency of plastic industry. The result show that the plastic produced could bear the weight one and half times more than petroleum plastic.

Ahmed Ibrahim Mohamed Ahmed et al. the economic income from industry saved it the leading position amongst all national and business plans. Increasing the efficiency of the production was the chief concern to mankind to increase income and suffice the needed goods. Pollution, industry supplies, energy and the efficient use of them were the highest obstacle grand challenges came in the way of industry. Every developed country depends on the industry as the main factor of its economy.

Khwanuddin et al. Plastic is a synthetic polymer material made through a polymerization process that cannot be separated from the daily life of society. The bio plastic sample was characterized such as physical properties (density, water absorption, biodegradability and functional groups) and mechanical properties (tensile strength, elongation and modulus of Young).

Patrícia Bataglini Franco et al. The tissue damage stimulates a coordinated physiological response to provide hemostasis and initiate the processes of inflammation, proliferation, and remodeling. This healing process is well known and occurs within 3 weeks for acute wounds but usually persist for a minimum of 12 weeks since the time of injury for chronic wounds. The extraction process was repeated three times. First and third extracts served as solvent to prepare

chitosan membranes by solvent evaporation technique. The chitosan membranes associated with the first and third extracts of unripe banana peel exhibit good flexibility, transparency, and uniformity.

Martien van den Oever et al. This report presents an overview of facts and figures regarding bio-based and/or biodegradable plastics, in particular for packaging applications. Often, the term bio plastic is used by the public. However, the term 'bio plastic' refers to either the bio-based origin of a plastic or the biodegradable character of a plastic.

III. BIOPLASTICS

3.1 Introduction

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:

- i. 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.
- ii. 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).

3.2 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.

3.2.1 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.

IV. METHODOLOGY

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.

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% Na₂S₂O₅ solution prior to the boiling processes. An 800ml beaker was filled with distilled water and placed over 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.

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 60°C. It was baked for half an hour.

4.3 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 2 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.

4.4 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.

4.5 Method and Experimental Procedure

Similarly sized bananas with no injury or bruises on the skin are purchased from the market in order to ensure the experimental process was fair.

4.6 Preparation of Banana Skins

Step 1: Banana peels are removed using stainless steel knife and converted into small pieces. Then peels are dip in sodium metabisulphite (0.2M) solution for 45 minutes. It is used as antioxidant and preservative. This would increase the biodegradation period of plastic.

Step 2: Banana peels are boiled in distilled water for about 30 minutes.

Step 3: The water is decanted from the beaker and the peels are now left to dry on filter paper for about 30 minutes

Step 4: After the peels are dried, they are placed in a beaker and using a hand blender, the peels are pureed until a uniform paste is formed.

4.7 Production of Plastic

Step 1: 25gm of banana paste is placed in a beaker

Step 2: 3ml of (0.5 N) HCl is added to this mixture and stirred using glass rod. Step 3: 2ml Plasticizer (Glycerol) is added and stirred. Step 4: 0.5 N NaOH is added according to pH desired, after a desired residence time. Step 5: The mixture is spread on a ceramic tile and this is put in the oven at 1200 C and is baked. Step 6: The tile is allowed to cool and the film is scraped off the surface.

V. METHOD AND EXPERIMENTAL PROCEDURE

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VI. RESULT AND DISCUSSION

In this project, the experiment conducted in order to form biodegradable plastic from banana peel. The plastic was formed after several experiment was made. The plastic sample produced may not achieving the ideal characteristic of a plastic but it is good in biodegradability as it can be composted in just 6 days. As the second test that is tensile strength test was made out to prove that the biodegradable plastic can be stretched as petroleum plastic can be stretched. To prove that we made the biodegradable plastic moulding process was carried out where the biodegradable plastic was moulded into several shape and dried until to get the moisture out and become hard. These results supported my hypothesis, meaning that we succeeded and manufactured biodegradable plastic from banana peels.



6.1 Degradation Test

The biodegradation test was recorded the amount of glycerine against the mass of the biodegradable plastic mould. Based on figure, it shown that the amount of glycerine increases so the degradation of plastic also much quicker. The amount of glycerine mixed is very important in making biodegradable plastic it gives elasticity and make the biodegradable plastic easy to degrade. As the graph stated that Initial weight have been taken is 100 gram with different amount of glycerine that is 20ml, 25ml and 30ml was used in biodegradable plastic. For the second day, the weight of the biodegradable plastic contains 20ml glycerine as reduced 0.03g, 25ml glycerine as reduced 0.8g, and 30ml glycerine as reduced 0.13g. At the fourth day the weight taken for 20ml glycerine is reduced 2.43g, 25ml glycerine as reduced 3.17, and 30ml glycerine as reduced 3.97g. As the Figure 1 shown the 25ml of glycerine was reduced the amount of weight higher than the 30ml of glycerine but for the following fourth day the 30ml of glycerine was recorded reduced higher than 25ml of glycerine. At the last day the 20ml of glycerine was reduced 3.54g, 25ml of glycerine was reduced 5.12g, and the 30ml of glycerine was reduced 6.60. As the Figure 1 shown the 30 ml of glycerine is faster degrade than the 25ml and 20 ml of glycerine. As the biodegradation test happens the darkening of the plastic suggested decay.

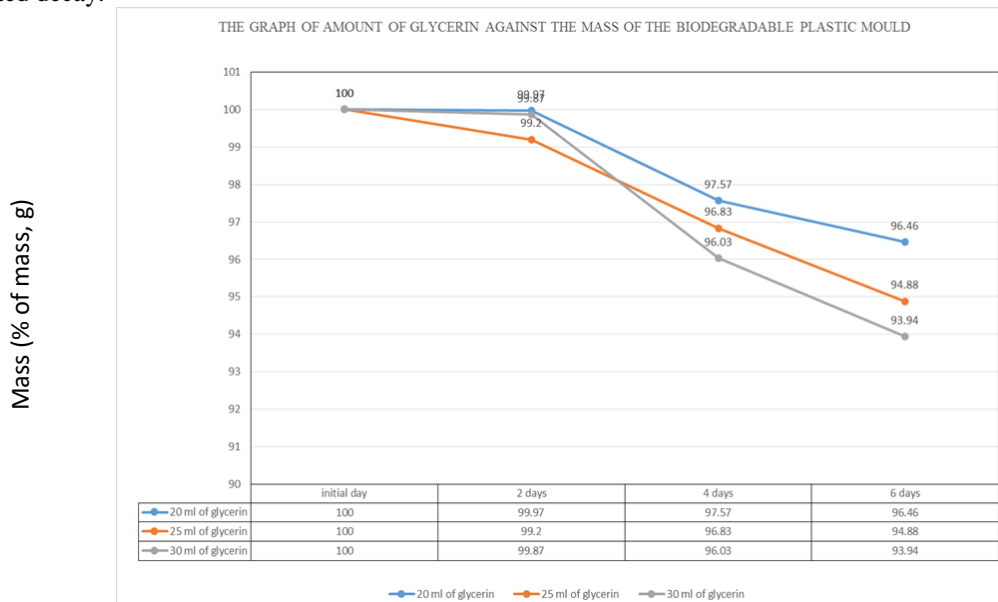


Figure 1: The amount of glycerine against the mass of the biodegradable plastic mould.

6.2 Elongation test

Figure 2 shows the elongation test on biodegradable plastic. As the figure 2 showing the initial length of the biodegradable plastic is 4.5cm and after it been stretched it become 6.5 length where it is the maximum strength of the biodegradable plastic that has been made. The strength of a strip of plastic is technically the force it can bear, under tension, per unit cross sectional area of the film, without breaking. The “cross sectional area” is measured as the width times the thickness. If want to do is increase the strength of your piece of plastic, the simplest thing to do is make it thicker: this would allow the piece of plastic to bear a greater load under tension without breaking. However, it would not increase the strength, which is a technical property of a plastic that doesn’t change with the size and shape of the piece of plastic you are considering. Tensile testing determines the amount of stress each material can sustain prior to failure as well as the amount of elongation at the time of failure.



Figure 2: Elongation test on biodegradable plastic

6.3 Moulding test

Figure 3 shows the biodegradable plastic mould. Moulding is the process of manufacturing by shaping liquid or pliable raw material using a rigid frame called a mould or matrix. This it may have been made using a pattern or model of the final object. Moulding is the process of forcing melted plastic in to a mould cavity. Once the plastic has cooled, the part can be ejected. As the figure 3 showing the biodegradable plastic that has been made is mouldable into various shape. Therefore, biodegradable plastic that have been made is a conventional plastic where it can replace the petroleum based plastic that is most popular amount the plastic moulding.



Figure 3: Biodegradable plastic mould

6.4 Biodegradability test (soil burial method)

The soil burial test provided a realistic environment where soil humidity, temperature, types and the amount of microorganisms were less in control and changed with seasons. All the tested films had same shape and size in order to avoid the effects of film's shape on it biodegradability. The loss of weight of the films monitored by means of sample collected from the soil at regular time interval. The films were buried in the soil and the sample was removed for evaluation at 2 days interval. It was observed that the degradation rate of the banana peel starch films increased continuously with the increase in the number of the days. Through the result obtained, it was observed that all the biodegradable bio-composite film expected for degradation process completely within 90 days whereas the film degraded completely within 15 days.

6.5 Mechanical properties test

A biodegradable composite film must withstand the normal stress encountered during its application. Elongation at break indicates the flexibility and stretch of the biodegradable composite films which determined at the point when the composite film breaks under tensile strength. The elongation at break value increased as the amount of starch increased. The elongation at break values was 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 elongation values as these decrease the intermolecular attractive force, improving the films flexibility and extensibility.

VII. CONCLUSIONS

From the consideration of all the above points we conclude that, Plastic pollution can unfavourably affect lands, waterways and oceans. Humans are also affected by plastic pollution, such as through the disruption of the thyroid hormone axis or hormone levels. Thus, the biodegradable plastic becomes a promising solution to solve all this problems. The objective of this study is 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. The strength of the film was determined using the elongation test by comparing the biodegradable film with a control film and a synthetic plastic. In the soil burial degradation test, the intensity of degradation was tested for all three types of film and the biodegradable film degraded at a rapid rate compared to control film while the synthetic plastic did not degrade at all. Based on all the testing that was carried out, the biodegradable film from banana peel is the best and ideal overall compared to the control and synthetic plastic. The films were prepared successfully by the mixing and casting method. The characteristics of the films with different glycerine content (20ml, 25ml, and 30ml) were evaluated using soil burial degradation test and manual. In soil burial degradation test, the compactness of biodegradable composite films was destroyed as the degradation time increases. A rapid degradation occurred for all the films 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.

REFERENCES

1. P. Prasteen "Bio-Plastics - An Alternative to Petroleum Based Plastics" International Journal of Research Studies in Agricultural Sciences (IJRSAS) Volume 4, Issue 1, 2018, PP 1-7 ISSN No. (Online) 2454-6224 DOI: <http://dx.doi.org/10.20431/2454-6224.0401001> www.arcjournals.org
2. M.R.GAONKAR "Production Of Bio plastic From Banana Peels" International Journal of Advances in Science Engineering and Technology, ISSN(p): 2321 -8991, ISSN(e): 2321 -9009 Vol-6, Iss-1, Spl. Issue-1 Feb.-2018, <http://iraj.in>.
3. Ravinder Singh "Bananas as underutilized fruit having huge potential as raw materials for food and non-food processing industries: A brief review" The Parma Innovation Journal 2018; 7(6): 574-580
4. Dr Reena "Biofuel from waste : A review" Special Issue on International Journal of Recent Advances in Engineering & Technology (IJRAET) V-4 I-1 For National Conference on Recent Innovations in Science, Technology & Management (NCRISTM)
5. Gaurav R. Dukare "Removal of Heavy Metals By Means of Banana and Orange Peels" International Journal of Innovative Research in Science, Engineering and Technology (A High Impact Factor, Monthly, Peer Reviewed Journal) Visit: www.ijirset.com
6. Jayachandra Yaradodd "Biodegradable Plastic Production from Fruit Waste Material and Its Sustainable Use for Green Applications" International Journal of Pharmaceutical Research & Allied Sciences, 2016, 5(4):56-66 ISSN: 2277-3657 CODEN (USA): IJPRPM
7. Noor Fatimah Kader Sultan "The Development of Banana Peel/Corn Starch Bio plastic Film:A Preliminary Study" Bioremediation Science and Technology Research Website: <http://journal.hibiscuspublisher.com/index.php/BSTRBSTR>, 2017, Vol 5, No 1, 12-17
8. Manasi Ghamande "Bio-Plastic Generating Plastic From Banana Peels" International Conference on New Frontiers of Engineering, Management, Social Science and Humanities, 25feb 2018
9. Ahmed Ibrahim Mohamed Ahmed "Banana peels based bio-plastic"
10. Ikhwanuddin "Manufacture Dan Characterization of Bioplastic Based on Stone Banana Leaves Powder and Carboxymethyl Cellulosa (CMC) Reinforced Gum Arabic" 2018 IJSRSET | Volume 4 | Issue 9 | Print ISSN: 2395-1990 | Online ISSN: 2394-4099 Themed Section: Engineering and Technology
11. Patricia Bataglini Franco "Chitosan Associated with the Extract of Unripe Banana Peel for Potential Wound Dressing Application" Hindawi International Journal of Polymer Science Volume 2017, Article ID 9761047, <https://doi.org/10.1155/2017/9761047>
12. Martien van den Oever "Bio-based and biodegradable plastics - Facts and Figures" Wageningen Food & Biobased Research, institute within the legal entity Stichting Wageningen Research April 2017
13. Prashant D Deshmukh "Cadmium Removal from Aqueous Solutions Using Dried Banana Peels as an Adsorbent: Kinetics and Equilibrium Modeling" Journal of Bioremediation & Biodegradation Journal of Bioremediation & Biodegradation ISSN: 2155-



14. Alvakonda Narayanamma “Natural Synthesis of Silver Nanoparticles by Banana Peel Extract and As an Antibacterial Agent”IOSR Journal of Polymer and Textile Engineering (IOSR-JPTE) e-ISSN: 2348-019X, p-ISSN: 2348-0181, Volume 3, Issue 1 (Mar. - Apr. 2016), PP 17-25 www.iosrjournals.org
15. Gajendra Kumar Rana “Potential Use of Banana and Its By-products: A Review”International Journal of Current Microbiology and Applied Sciences ISSN: 2319-7706 Volume 7 Number 06 (2018) Journal homepage: <http://www.ijcmas.com>