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Bioplastic From Jumbled Fruit Peels - A Budding Attempt

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Abstract: In *the modern society with escalating population, plastics play a elementary role in almost all the sectors of day-to-day life for packaging materials. These plastics do not degrade easily as they are unassailable to the microbial decomposition and hence persist in the environment for a long time. Hence the 21st century generation technologies focused on the production of bioplastic from waste sources/non-edible things that are in great demand to reduce the risks of ill effects caused by plastics. Bioplastics are produced nowadays from numerous sources such as potato waste, mango seed, grape waste, pumpkin seed, sugar bagasse, coffee waste, banana waste, avocado seed, carrot waste, peanut husk, cereals straw and citrus fruit waste. Keeping in view of all the regards of the advantages of bioplastics in the mind the present study has made a new attempt to produce bioplastic from a mixture of fruit peels which is a novel attempt to produce bioplastic with all the remarkable properties of the fruit peels.*

Keywords: Banana, Musk melon, orange, Dragon fruit, Bioplastics.

I. INTRODUCTION

The major sources of land pollution include plastics, metal and glass containers, food wrapping, worn-out machinery, old furniture, garbage, etc (FAOSTAT,2011). Plastics have become a large environmental problem. The plastics in excess produced will be deposited as a landfill and are degraded very slowly, which can cause the original products to remain in the landfills for hundreds or even thousands of years (Babatunde *et al.,*1992). The prominence of plastic pollution is correlated with plastics being economical and durable, which lends to high levels of plastics used by humans. However, it is slow to degrade and plastic pollution can unfavorably affect lands, waterways and oceans. Living organisms, particularly marine organisms which includes both the flora and fauna, can also be affected through entanglement, direct assimilation of plastic waste, or through contact with chemicals within the plastics and cause interruptions in bio functions of the living organisms. Even humans are also not free from the hazardous cause of plastic pollution; they suffer from the disruption of the thyroid hormone levels. Plastic reduction efforts have occurred in some areas in attempts to reduce plastic consumption and pollution and promote plastic recycling. Due to the use of excessive chemical additives during plastic production, plastics have potentially toxic and that could prove to be carcinogenic. Some of the principal additives are used as phthalate plasticizers and brominated flame retardants (Chaparadza *et al*., 2012). Therefore, nowadays scientists are looking at potential alternative to the traditional plastics derived from petrochemical source.

Bio-based plastics mean plastics produced from renewable resources. The pattern of production is shifting from the true biodegradable plastics to the bio-based plastics, and that trend is likely to persist in the future. They can be derived from renewable biomass sources, such as vegetable fats and oils, corn starch, pea starch, or micro biota. There are a variety of materials that bioplastics can be composed of, including: starch, cellulose or other biopolymers (Noor Fatimah Kader Sultan *et al.,*2017). 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 (Gaonkar,2017).

Biodegradable and biocompatible polymers are nowadays gaining importance worldwide in both basic and applied research fields such as pharmacological, biomedical and environmental applications. These bio polymers exhibit the characteristic features of highly functionalized globular nature, interstellar polymers exhibit different properties from those of their linear counterparts, such as less entanglement in the solid state , high solubility in numerous solvents, low melt viscosity (Zhou *et al*., 2007) and fast molecular motion. Biodegradable plastics are of two types; one is plastic materials which will be decomposed in natural aerobic (composting) process and another is decomposed in anaerobic (landfill) environments. Degradation occurs when the soil microbial consortia start consuming these polymers and eventual release of monomers to the environment certainly has less hazardous effects on the landscape. These polymers are either composed of bioplastics (PHA or PHB) or plastics which are derived from renewable raw materials or petroleum based plastics which contains additives. Polymer additives play a critical role in the modern plastics industry in order to overcome the difficulties in processing, to enhance material durability and which will help product designers to manufacture a pliable, trendy, user friendly and efficient products. Most of the plastics synthesized were blended with either organic or inorganic compounds, however the average content of additives will be 20% of the total weight of the polymer. However, the present study provides some possible methodologies which are very adequate and has potential outcome to check the quality of product that are produced using the bioplastics materials. The materials which are synthesized using banana peel is having the properties of pliability, user-friendliness and the most importantly these materials are degradation tractable. The bioplastic obtained will be environmentally friendly, trendy, user friendly and degradation tractable properties. (Jayachandra Yaradoddi *et al*., 2016).

These bioplastic plastics usually derived from renewable energy resources like corn starch, potato, tapioca, sugar cane bagasse, and algae. In general, they are either fully or partially biodegradable/compostable by their properties . However, biobased plastics suffer from few problems in processing, and they require polymer additives to enhance their tensile strength and flexibility, but it will result in trendy, user-friendly products (Liang W, 2018). Polylactic acid (PLA), the second most crucial bioplastic in the world in terms of consumption in volume, and is a transparent biobased plastic /produced using corn or dextrose. This bioplastic material shows similar characteristics features as that of conventional plastics (Norgren M *et al.,* 2014). Scientists have stated that the use of natural fibers in biodegradable materials development. Further demonstrated that these materials are safe to use, and the most precise reason existed in their high specific strength to weight ratio. However, it is authoritative that natural fibers should be physicochemically modified to enhance their compatibility and adhesion between them and the matrix . The present research work's effort is to provide a promising bioplastic that should have less/zero harm to the environment, likely meager cost of production, and availability as alternate materials upon the conventional and banned plastic based on the changing requirements of the modern society. In earlier reports fruit peels like ,Orange,banana citrus fruits and many other starch based materials are used for the production of bioplastics. Keeping in view of all the regards of the advantages of bioplastics in the mind the present study has made a new attempt to produce bioplastic from a mixture of fruit peels which is a novel attempt to produce bioplastic with all the remarkable properties of the fruit peels. The present study has taken banana , musk melon, dragon fruit and orange as the natural source for producing the bioplastics. The fruit peels of all the above fruits are considered as rich sources of pectin and starches and other vitamins , minerals and flavanoids. Hence they act as a best source for the production of bioplastics . In earlier reports the bioplastics were produced from banana peels, orangepeels etc., as a individual component . But the current study aims at the production of bioplastics for the first time from the mixture of fruit peels.

II. MATERIALS AND METHODS

COLLECTION OF SAMPLE

Figure 1 Fruits chosen for study

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Fresh and healthy fruits namely Orange,Dragon fruit,Musk melon and Banana were purchased from the food court of M.G.R.College campus and was considered as the sample. After consumption of the fruits , the fresh peels were collected and washed thrice in distilled water and were used for further study. The chemicals needed for the present study were of analar grade .

DETERMINATION OF CARBOHYDRATES IN THE FRUIT PEELS

Carbohydrates are biological molecules consisting of carbon, hydrogen and oxygen atoms. The Empirical formula is (CH2O) n, where n is the number of repeated units. Carbohydrates are divided into three main classes depending upon the complexity and behaviour on hydrolysis such as monosaccharides, oligosaccharides and polysaccharides. The word “saccharide” is derived from the Greek word sakcharon, meaning sugar.High carbohydrate content of a substance makes it a better source of bioplastic (Lusiana *et al*., 2019). Thus, before the peels of all the four different fruits were choosen for making bioplastic, tests for carbohydrates were conducted to find the presence or absence of them in the peels. The standard protocol of (Jahan girpuria *et al*.,2017) was followed for performing the tests.

PREPARATION OF THE PEEL EXTRACT :

Fresh peels of all the four different fruits were cut into small pieces. Ten milligrams of the mixed fruit peels were grinded and dissolved in 10 ml of distilled water . The grinded extract of the peels were tested for the presence of carbohydrates by the following standard tests.

Figure 2 – Tests for Carbohydrates

Molisch’s Test :

Procedure: 2 ml of the peel extract was taken in the test tube and 2-3 drops of Molisch’s reagent (alpha-naphthol solution) was added.. To this ,1ml of concentrated Sulphuric acid was added slowly at the sides of the test tube.

Benedict’s Test :

Procedure: 2 ml of the extract was taken in the test tube and to this 5ml of Benedict’s solution was added.Then the test tube was kept in a boiling water bath for 3 minutes and then allowed to cool.

Barfoed's Test:

Procedure: 2ml of the extract was taken in the test tube and to this 2ml of Barfoed's reagent was added. Then the test tube was kept into a boiling water bath for 3 minutes and then allowed to cool.

PREPARATION OF MIXED FRUIT PEEL PASTE:

Figure 3 – Chopped fruit peels

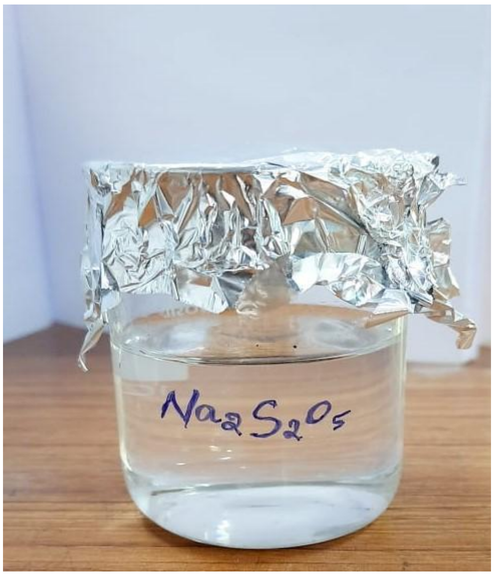

Figure 4 - Sodium metabisulphite

Figure 5 – Fruit peels soaked in Na_2S_2O

Figure 6 – Fruit peels Boiled in water

Figure 7 - Dried Fruit Peels

Approximately ten grams of fresh peels of individual fruits namely Banana, Musambi, Musk melon and Dragon fruit were weighed and cut into small pieces. Initially they were washed with distilled water and then totally about 40 grams of the mixed fruit peels which was finely chopped was soaked in sodium metabisulphite (0.2M) solution for 45 minutes. It is used as antioxidant and preservative. This would increase the biodegradation period of bioplastics. Mixed fruit peels were boiled in distilled water for about 30 minutes. The water was decanted from the beaker and the peels of all the fruits were left to dry on filter paper till it gets completely dried. For better results the peels were kept in hot air oven for ten minutes. After the peels were completely dried, they were placed in a pestle and mortar, the peels were made into fine paste. The paste was stored for further use (Arjun *et al*., 2023).

PRODUCTION OF BIODEGRADABLE PLASTIC FROM THE FRUIT PEEL PASTE

Figure 8 – Mixed fruit peel paste

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Twenty five grams of the mixed fruit peel paste was placed in a beaker 2 teaspoon of cinnamon powder was added which would provide the antimicrobial property of bioplastics. 3 ml of (0.5N) HCL was added to this mixture which helps in film formation. 2 ml of Glycerol was added which act as plasticizer. 3 ml of NaOH was added to maintain pH. The mixture was poured in a mold and put in the oven at 130`C at least for one hour . Some amount of the paste was spread on a porcelain tile and was placed under the oven at 130`C and was kept till complete drying.. Later stage the mold and the tile were allowed to cool and the plastic film was scraped off from the surface. (Arjun *et al*., 2023).

III. CHARACTERISATION STUDY OF THE FORMED BIOPLASTIC - FTIR (Fourier Infrared Transformation Spectroscopy)

Figure 9 – FTIR Instrument

A small piece was cut from the bioplastic film was placed onto the germanium plate. The spectra were taken in 256 scans between 4000 and 500 cm-1 using the Spectrum 100 Perkin Elmer FTIR. The test was carried out in the TRIBIOTECH research Institute , Trichy. This was done to done to analyse the functional groups involved in the formation of bioplastic (May Zon Kyawt Oo *et al*., 2019).

WATER ABSORPTION TEST

Figure 10 – Bioplastic Soaked in water

A small piece of the sample was cut into 1 cm × 2 cm size. The initial weight of the sample was recorded. The sample was then placed into a beaker containing 60 mL of water at room temperature for 24 hours.The sample was then taken out from

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the water and wiped off. The final weight was recorded. The amount of water uptake was calculated by using the following formula:

WA% = Final weight (g)-initial weight (g) / initial weight x 100

SWELLING TEST

Figure 11 Bioplastic in different solvents

Swelling study is generally conducted to check whether developed material retains the original properties when it was formed during the preparations. A pre-weighed piece of samples were prepared were taken in the test tube to check the protuberance and other morphological changes, it was carried out on the medium containing various solvents such as water, chloroform and methanol medium. Where the deliberated samples were kept in the medium for about 2 hours and the results were recorded accordingly (Jayachandra Yaradoddi *et al*., 2016).

SOLUBILITY TEST

Figure 12 – Bioplastic in soaked in different solvents

Solubility studies were conducted to check persistence of these bioplastic materials. Samples of bioplastic formed from the mixed fruit peels were cut into small pieces and were inserted into a reagent bottles containing different solvents namely Ammonia, Acetone , Ethyl alcohol, Sulphuric acid and water.(Jayachandra Yaradoddi *et al*., 2016).

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BIODEGRADATION TEST:

An aluminium tray with the garden soil was taken and divided into two portion . In one portion a piece of the formed bioplastic was taken and then it was buried in 5 cm depth. On the other side a piece of commercial plastic paper was buried in 5cm depth and was compared. At regular time interval, water was sprinkled. About 2 days time interval, the specimen from the soil was taken and washed with distilled water, after that specimen was dried and the weight was taken (Deeneshwaran *et al*., 2016).

Figure 13 Biodegradability test

MOLDING TEST

Figure 12 **Figure 12.1**

Molding is the process of manufacturing by shaping liquid or raw material using a rigid frame called mold. This may have been made using a pattern or model of final object. Once the paste is formed it is forced into mold cavity. Once the material gets rigid, it can be ejected.This test was done with the formed bioplastic and it was spread into a cup shaped mold which can be used as a plant pot.(Arjun *et al*., 2023)

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PLANT GROWTH TEST

Figure 13 Biodegradable Plant pot with sown seeds

Plastic pots are commonly used to grow plants, biodegradable plant pots can be used as alternatives for plastic pots. Plants are grown in biodegradable pot as well as commercial plastic cover and water is poured daily to check the viability of the biodegradable pot. In this aspect the molded bioplastic cup was filled with soil and seeds were sown to observe the growth of plant.

IV. RESULTS AND DISCUSSION

In the current study mixture of fruit peels were taken for the production of bioplastics.The results of the present study are presented and discussed below:

DETERMINATION OF CARBOHYDRATES

Before the formation of Bioplastic the peels were checked for the presence of carbohydrates. The results of the tests are presented below:

No.	Test	Observation	Inference	Reaction
1.	**Molisch's test**	A deep violet colour is produced at the junction of the two layers.	It shows presence of carbohydrates.	It is due to the formation of unstable condensation product of alpha-naphthol with furfural (produced by the dehydration of carbohydrate).
2.	**Benedict's test**	Formation of red, green or yellow precipitate.	It shows presence of reducing sugars.	If the saccharide is a reducing sugar, it will reduce copper Cu (II) ions to Cu(I) oxide, and form red precipitates.
3.	**Bradford's test**	A deep blue colour is formed with red precipitates settling down at the bottom or at sides of the testtube.	It shows appearance of reducing sugars. If the ppt. formation takes time, then itshows the presence of reducing disaccharides.	If the saccharide is a reducing sugar, it will reduce Copper Cu(II) ions to Cu(I) oxide.

Table 1 – Tests of Carbohydrates

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Figure 14 – Qualitative Tests of Carbohydrates

The above result s from the Table-1 and Figure -14 clearly depicts the presence of carbohydrates in the mixture of fruit peels.Same results were obtained in earlier reports (Manali Shah *et al*., 2022).

PRODUCTION OF BIOPLASTIC

Figure 15 – Bioplastic formed from the fruit peels

The above figure 15 illustrates the clear image of the formed bioplastic that was spread in the tiles . The formed bioplastics have the following characteristics:

- **Colour:** The colour of bioplastic varies from source to source. In this experiment, mixed fruit peels wereused . Hence, the bioplastic developed was of yellowish-orange colour.
- **Texture:** Texture of the bioplastic film can be determined by touching the surface. The complete blended mixtures of the peels lead to a smooth texture from the bottom and rough texture from the top surface.
- **Transparency:** Almost all bioplastics are transparent but some are semi-transparent. Here in the current experiment the bioplastic film made from mixed fruit peels was semi-transparent.
- **Odour:** The odour of the bioplastic was like fermented fruit juices, but due to the application of differentchemicals the pungency was present.

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FTIR RESULT

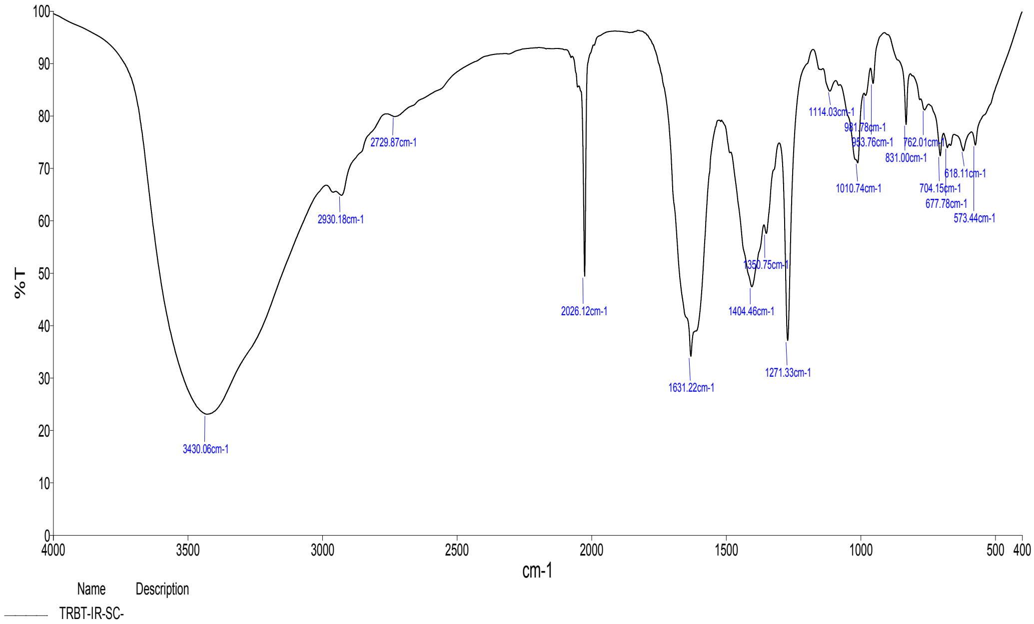

Figure 16 FTIR Spectrum of the Bioplastic

FTIR Spectroscopy was used to investigate the interactions between different components and changes in chemical compositions of the mixtures. FTIR measurements for synthesized bioplastic film were carried out to identify the possible biomolecules present in the bioplastic. The result of FTIR analysis of synthesized bioplastics is shown in figure 16. The results of FTIR analysis of the sample showed revealed that FTIR spectrum of the sample was obtained at the wavelength in the range of 400 – 4000 cm^{-1} .The results of the study also showed that the peak at 3430 cm^{-1} is due to primary amine that produce 2 N-H stretch absorptions, peak at 2930 cm^{-1} was attributed to the alkane C-H bonds. Stretching at 2729 cm^{-1} and 2026 cm^{-1} was due to carboxylic O-H stretching, peak at 1631 cm^{-1} was due to C=O stretch. Thus the spectrum coincides with the earlier reports (Noorjahan *et al*., 2022).

WATER ABSORPTION TEST

The produced bioplastic were determined to have a water uptake percentage more than 50% because biopolymers are hydrophilic in nature. The water absorption percentage was found to be 75%. Besides, the water molecules interact with hydroxyl group in starch structure, the plasticization of biopolymer with glycerol is also an important factor in this study. As glycerol is a hydrophilic low molecular carbohydrates, it has the tendency to adsorb water depend on the number of hydroxyl group present and molecular weight of it structure. Glycerol has three carbons attached to their backbone with one hydroxyl group attached to each carbon which causes the molecules to bind to the highest amount of water corresponding to the weight portion. Increasing sizes of hydroxyl groups concentration centre in biocomposite matrix increases the water absorption of the film. Thus the produced bioplastic was found to have more water holding capacity which is found to have more applications in commercial use. Similar reports were reported in earlier studies also (May Zon Kyawt Oo *et al*., 2019).

SWELLING TESTS

Solvent Medium	**Quantity (ml)**	**Initial Weight of the Sample (gm)**	**Final Weight of the Sample (gm)**	**Difference of Weight (gm)**
Water	20	**0.5**	**0.95**	**0.45**
Chloroform	5	**0.5**	**0.60**	**0.1**
Methanol	5	**0.5**	**0.56**	**0.06**

Table 2 – Results of Sewlling tests of the Bioplastic

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The above Table 2 indicates the result of swelling tests.There is no difference observed in the integrity of bioplastic material when the bioplastic material which is soaked in chloroform and methanol solvents. However, there is a slight increase in the weight of bioplastic material when it is soaked in water has made it a reliable material than other materials. The apperance of the bioplastic hasn't changed much, but there is a slight increase in the weight of the samples after 2 hours. Swells little higher in water as a medium and this is a desirable result because most of the additives are prepared by using organic solvents, certainly it will help in stabilize product synthesis and development. In another research of bioplastics observed the similar results in their work ((May Zon Kyawt Oo *et al*., 2019). This shows that the formed bioplastics shows the similar property of bioplastics formed from individual fruit peels.

SOLUBILITY TESTS

SOLVENTS	SOLUBILITY
Ammonia	Partially Soluble
Acetone	Partially Soluble
Ethyl Alcohol	Insoluble
Sulphuric Acid	Insoluble
Water	Insoluble

Table 3 – Results of the Solubility of the bioplastic

Results for solubility study of bioplastic is shown in Table 3. None of the samples were completely soluble in the different medium used and these are certainly desired results for preparation of bioplastics in comparison to the traditionally used and shows the bioplastic materials prepared using the banana peel is stable. Solubility are the main properties to check whether the synthesized bioplastic material is sustainable or not. If the bioplastic material possesses the property of less or zero engorgement property that can be considered as excellent material with stability as characteristic features. Thus the formed bioplastic was insoluble in different solvents and is apted for commercial use as reported in many earlier studies.

BIODEGRADATION TEST

Figure 17 Day 1 of Soil burial test

It was observed from the biodegradability test that the prepared bioplastic film got completely degraded in the soil where as the commercial plastic was found to be non biodegradable. Initially in day 1 the formed bioplastic was about 5.53 gms. After 15 days the weight got reduced and finally found to be degraded almost in the 30^{th} day. The sprinkling of water enhanced the enzymatic activities of the microorganisms of the soil. The carbohydrate constituents present in the fruit peels provide carbon sources which further helped in growth and multiplication of the soilmicroorganisms (Yaradoddi et al., 2022).Thus the produced Bioplastic was found to be degradable and was safer to use in many ways.

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MOLDING TEST


Figure 18 - Molded Bioplastic from fruit peels

The bioplastic produced in the current study was poured into a cup shaped mold and also was spread on tiles. But after drying in the oven it was found to be dark brown or balck in colour and can be molded into any shape. In this study the formed plastic was shaped as a cup of a tiny plant pot inorder to use it as plant pots.It was found tobe molded into our desired shape with smooth and flexible nature. The above figure shows the final product .

PLANT POT TEST

The prepared bioplastic which was molded as a cup was filled with soil and seeds were sown in it. Figure 19 shows the growth of seedlings in the biodegradable plant pots. The pot holds water well when compared to the commercial plastic bags. So it is easier to grow plant in such biodegradable pots so that it can grow well with more water holding capacity.

Figure 19 – Biodegradable plant pot from the produced bioplastics

V. SUMMARY AND CONCLUSION

Owing to the ill effects of Plastics to the environment the present research work with an emphasis on the synthesis of bioplastic material by using a fruit waste from jumbled fruit peels. Bioplastic can be defined as plastic made of biomass such as corn, banana peels and sugarcane and starch basd resources. Making bioplastics from fruit peels instead of traditional petroleum-based plastic is believed to be a successful solution to increase the efficiency of the plastic industry.

The polymer produced using the fruit peels blended with the glycerol could help in the formation of plastic having the characteristic features of pliability, other tests like solubility and swelling studies were conducted to ensure commercial properties of these bioplastic materials,. Thus the produced bioplastic from the mixture of fruit peels like banana, musk melon, Musambi and Dragon fruit was tested with different tests like Swelling, Solubility , water absorption and Biodegradability by soil burial test. It was also characterized by FTIR, which confirms the polymer is bioplastic. One of the most significant results obtained during the research is degradation tractability of the developed product.

The formed Bioplastic from the jumbled fruit peels has high water holding capacity, biodegradability and can be molded into different shapes.Thus the produced bioplastic is a biodegradable and an environment friendly alternative compared to conventional plastics. Research into bioplastic development should continue so that bioplastics with more diverse applications can be created from fruit waste. The main advantage of bioplastics over conventional plastic is that they degrade into environment without creating any pollution. Bioplastics is one the best replacement over conventional plastic. By using such biodegradable natural resources as a raw-material in the production of Bioplastics we can produce good quality bioplastics which has good life.