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Environmental Revolution: How to use potatoes to create sustainable bioplastics

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- **Abstract**:

Traditional plastic materials have become one of the materials that represent severe harm to the environment because they are non-biodegradable materials, as they are considered derivatives of organic materials that are very stable and large in molecular size. Starch is a natural polymer consisting of many units of glucose in the form of a large polymer. In this project work, potatoes were chosen as plant tubers in the preparation of biodegradable plastic films. Starch powders were prepared from potatoes by washing, cutting, grinding, drying and crushing. Then the biodegradable plastic film was prepared using starch powder, water, acetic acid and glycerin as plasticizers. In this project, starch extraction from selected tubers with high starch content namely potato was used as raw material for bioplastic. The chemical, Sensory, water uptake and biodegradable properties of the products were analyzed using FTIR spectroscopy. Where the infrared spectra revealed the presence of absorption values for the groups hydroxyl, carbon-hydrogen, carbonyl and carbon-oxygen, this confirms that the biodegradable biopolymer and bioplastic may have actually been synthesized. The good ability to biodegrade the plastic was confirmed using a soil burial test, which was observed by calculating the soil decomposition rate of potato-based bioplastic in a period of 10 days, which amounted to 24%. Through previous experiments, it became clear that these synthetic plastic materials from natural sources have good sensory and chemical properties and also have a good degree of biodegradability. This makes these synthetic plastic materials considered a good alternative to plastic materials derived from organic sources that lead to pollution of the traditional environment.

Key Words:

Potato starch, glycerol as plasticizer, Sensory property, Synthetic polymer.

1. **Introduction**: **Manufactured natural polymers play an important role in many industries, which are used in storing many necessary materials. In any event, it has an impact on the environment and creates problems with waste management. Food storage materials today include glass, some types of paper, and a group of plastic polymers generated from organic materials. Plastic is made to be the best of these storage materials due to its long-lasting qualities and as a result, its use is increasing daily. Since plastic does not decompose through several specific cycles in a specific time; Therefore, when left as waste, it causes many problems that affect all organisms in terms of pollution and many chronic diseases. Regular waste disposal operations are not suitable for destroying plastic. The creation and manufacture of biodegradable plastics has attracted much attention in light of these issues related to plastic waste [Pablo, R. et al]. Finally, the presence of strong bonds between molecules in traditional plastics makes them stronger and thus takes a very long time to biodegrade. We find that some fungi and bacteria consume synthetic biodegradable plastic materials and break them down. Polymers derived from natural sources such as potatoes, which are biodegradable, have been developed using biological processes based on modern technology. These resulting polymers are called green plastics and are derived from some plants. Modern scientists are interested in this green plastic since it is a byproduct of conventional polymers made of chemicals [Tharanathan, R.N. et al], green plastic should come from renewable resources and be environmentally beneficial and biodegradable. A biodegradable polymer, starch is produced in large quantities with minimal consumption and shows the desired flexibility. Starch, an endless resource, appears to be the most cost-effective raw resource for biodegradable polymers. A variety of starches, such as those found in potatoes, have been studied as potential agents for the formation of plastic films. As a result, it is now the most likely alternative material to traditional plastics in some niche markets. In this study, a biodegradable plastic film was created by combining potato starch and**

glycerol. Films made from starch are strong, flexible, odourless, colorless and naturally biodegradable [Flores, S. et al]. Potatoes are one of the world's essential horticultural products. Biodegradable storage films based on potato starch are produced using casting technology. Recently, synthetic polymer materials have been widely used in various fields of life. These synthetic molecular materials usually originate from organic materials, and most conventional materials are considered non-biodegradable. The increasing use of non-biodegradable polymers has led to numerous environmental problems. Since food is an essential part of our daily lives nowadays, and the majority of food products come in plastic containers, there has been increasing interest in biodegradable polymer materials. Packaging has become a very important field as biodegradable polymers can be used in many areas of daily life. To meet consumers' needs for more environmentally friendly packaging, it is necessary to improve the quality of various products by using biodegradable polymer-based films. In addition to their biodegradability, biopolymers offer many advantages, such as air permittivity, temperature tolerance, availability, and durability [Cutter, C. N. and Satyanarayana, K. G. et al]. Biodegradable polymers are created to perform their functions without posing any risk to the environment. It is believed that these materials can reduce the need for synthetic polymer production, leading to reduced environmental pollution and cost reduction, thus providing many environmental and economic benefits. The main objectives of this research were to create biodegradable plastic films derived from potato starch and evaluate their suitability for food storage. These biodegradable plastics have demonstrated excellent thermal properties and high biodegradability, making them a viable alternative to organic plastics.

2 . THE THEORETICAL FRAMEWORK

As a result of waste sites being filled with non-degradable materials, which negatively affect the environment, causing great harm to all living organisms, many are calling for the production of synthetic biodegradable plastic bags from natural sources. The materials used

in their formation have led to the emergence of various harmful chemicals that get worse over time. With the presence of harmful compounds such as freons, the ozone layer has been completely deprived. So, scientists and conservationists have managed to overcome this danger, but not completely. To overcome these damages, environmentally friendly products have been created from recycled or natural materials. So scientists and researchers use natural resources to create an alternative to organic plastic. The new synthetic type of plastic has attracted many environmentally conscious people by demonstrating the clear effects that can be obtained from using an environmentally friendly product. Therefore, scientists and researchers are better seeking to discover and develop many biodegradable plastic products. The aim of the study is to identify other natural materials that can be used in the production of biodegradable plastic bags, such as starch.

3. MATERIAL AND METHODS

A. Materials used:

potato starch, glycerin and acetic acid. Starch extracted from potatoes is used to prepare a biodegradable plastic layer from starch. The role of glycerin is to act as a plasticizer in the film solution to increase its flexibility, while acetic acid is also added to the solution. Adding acetic acid to increase the antibacterial effect of biodegradable films and to improve the Sensory properties and water vapor permittivity, adding distilled water to the solution also acts as a plasticizer and reduces the weakness of plastic films.

B. Preparation potato starch:

*There are several steps used before extracting starch from potatoes. It consists of:

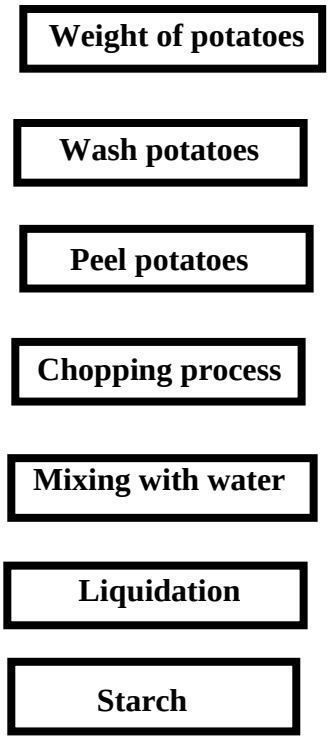
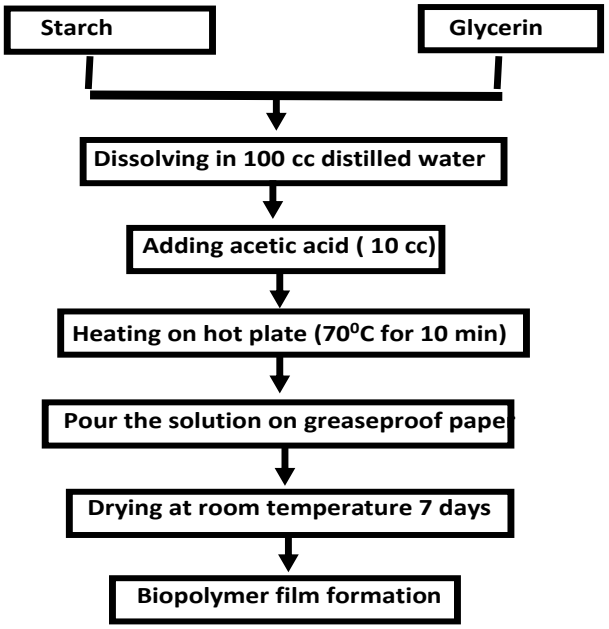


Figure 1 Tools used in the project

C. Biopolymer synthesis

Take 15 grams of potato starch and put it in a cup. Then add 100 cc of water to the beaker and stir. Add 10 cc of vinegar to the beaker, then add 10 cc of glycerin to the beaker, add two drops of food coloring and stir. Then place the bowl on a hot plate at 70^{0}C for 10 min. and stir constantly until the mixture thickens.

When it becomes jelly-like, pour it onto greaseproof paper with foil underneath Leave the plastic to dry for at least 7 days.



Process flow chart for formation of starch based Biopolymer film.

Figure 2 Stages of bioplastic formation

4. RESULTS AND INTERPRETATION

Through the analysis results of plastic films prepared using potato starch, we find a higher resistance to absorption of water and moisture than traditional plastic films. It was also found that these plastic films are completely soluble in the basic medium.

The dissolution test of biodegradable polymerized plastic film in different solvents is described in Table I. When the solubility of prepared bioplastic films in different solvents like C_6H_6, $CHCl_3$, C_2H_5OH ,CH_3COCH_3, C_2H_5OH and CH_3OH were investigated both at room temperature (25ºC-27ºC) and at 50ºC. The polymerized plastic film was found to be insoluble at room temperature but the film dissolved completely in C_2H_5OH and CH_3OH at 50°C.

Table I

Sample Number	Solvents	Potato Starch	
		Room Temp:	50˚C
1	Benzene	Insoluble	Insoluble
2	Chloroform	Insoluble	Insoluble
3	Acetone	Insoluble	Insoluble
4	Ethanol	Insoluble	Soluble
5	Methanol	Insoluble	Soluble

Biodegradable properties. Table II shows the loss in mass and biosynthetic plastic exposure in the soil burial test on several different days. The decrease in the weight of the synthetic plastic while buried in the soil indicates the amount of dissolution in the natural environment due to some bacteria that will cause breakage. The polymer chain thus causes biodegradation [S. Khoramnejadian, et al].

Table II

Sample Number	Time	Potato Starch		
		W_1(g)	W_2(g)	W(%)
1	2 days	0.29	0.25	4
2	4 days	0.29	0.21	8
3	6 days	0.29	0.16	13
4	8 days	0.29	0.10	19
5	10 days	0.29	0.02	24

The percentage of biodegradation (W) that has taken place can be calculated through the following equation. 1:

$$W\ (\%) = [(W_1 - W_2) / W_1] \times 100 \quad (1)$$

whereby W_1 and W_2 , is the initial and final weight of biodegradable plastic.

Figure 3: Biodegradation of the Bio-Plastic Sample

According to the percentage of weight loss, the plastic made from potato starch showed a degree of biodegradation of 24%, within 10 days. This is due to the starch content in potatoes requiring time to decompose [A. Moongngarm and K. Scott-Dixon, et al].

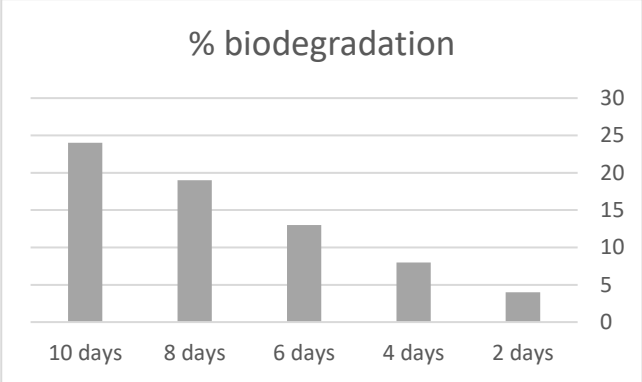


Figure 4 Weight loss

Table III shows the sensory properties of the synthetic biodegradable plastic films. It turns out that the synthetic plastic polymer using

potato starch is white in colour, odorless, flexible, soft and slightly stretchable.

Table III Sensory Properties

Sample Number	Characteristics	Starch
1	Colour	White
2	Odour	Odourless
3	Texture	Smooth
4	Transparency	Translucent
5	Flexibility	Very stretchy

Figure 5 shows Fourier Transform Infrared Spectroscopy of the biodegradable synthetic polymer, and the active groups are written in Table IV.

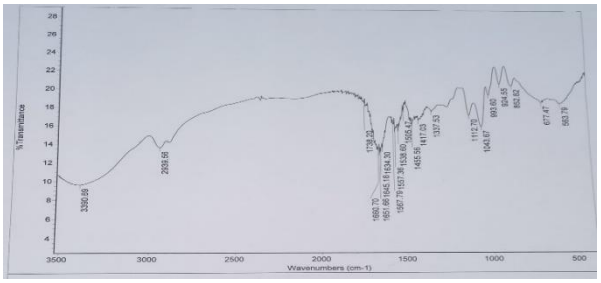


Fig.5

Table IV of active groups in the polymer

Sample Number	Observed wavenumbers (cm^{-1})	Effective band
1	3390	O-H stretching vibration
2	2930	C-H stretching vibration
3	1738	C=O stretching vibration
4	1043	C-O stretching vibration

Perform a water absorption test. Due to the biosynthetic plastic's affinity for water, potato starch, the main ingredient, is responsible for water absorption. The experiment is carried out by weighing different dry samples and leaving them in water for several different hours and recording the results in Table V.

(a) before (b)After

Figure 6 water absorption test

Table V : Experiment of absorption

Sample Number	Time, h	Weight Dry (gm)	Weight wet (gm)	absorption (%)
1	2	0.25	0.28	12
2	4	0.35	0.42	20
3	6	0.45	0.57	27
4	12	0.55	0.80	45
5	24	0.65	1.10	69

It was found that the weight of the samples before and after the first experiment increased, as the percentage of absorbed water can be calculated through Equation 2.

Percentage of water absorbed =

[Weight $_{wet}$- Weight W_{dry} /Weight$_{wet}$] × 100 (2)

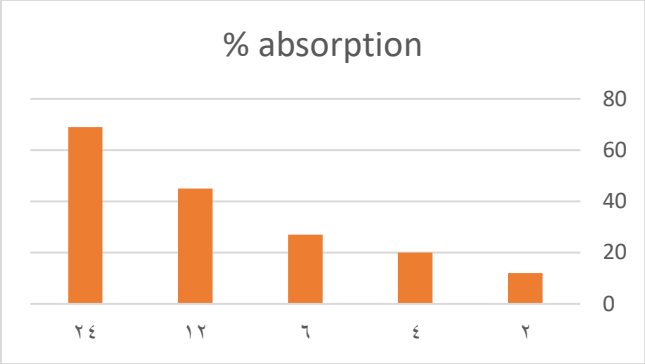


Figure7 absorption % , time

5.Conclusion

Bioplastics made from starch extracted from potatoes are very important alternatives to traditional plastics based on organic materials extracted from petroleum due to their distinct properties. In this study, it can be concluded that starch-based bioplastic has been successfully synthesized from potatoes. These products have high properties such as biodegradability with distinct properties that make them a suitable alternative to existing traditional plastic materials. Furthermore, starch is a renewable resource, cheap and easily modified. This means that one day it will no longer be necessary to rely on petroleum to prepare bioplastics, as people can "grow" potatoes from the ground, and the problems will no longer exist as they do at this time.Also in this study, biodegradable plastic films were created from potatoes using glycerin as a plasticizer and acetic acid and water as solvents. It was found that potato tubers contain the largest percentage of starch raw materials, are cheap, available in abundance, and can be obtained without trouble. Therefore, starch extracted from potatoes can be used to prepare biodegradable plastic films as food storage materials. Based on the chemical phenomena and sensory, absorbent and biodegradable properties of the prepared plastic films, it can be concluded that the synthetic plastic polymer based on starch extracted from potatoes was found to have better resistance to chemicals, and a faster soil biodegradation rate than conventional plastic. It was found that the bioplastic film prepared using potato starch is distinguished by its flexibility and transparency. Compared to traditional plastic materials, potatoes based on biodegradable plastic films are environmentally friendly materials that can be used to store most food materials.

The functional group OH, C-H, C=O and C-O indicates the formation of the starch-based synthetic bioplastic which was confirmed by FTIR spectroscopy. Therefore, we can also come up with a synthetic bioplastic film that can be used to reduce environmental pollution as well.

THANKS

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