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# MECHANICAL PROPERTIES OF JUTE FIBER REINFORCED POTATO WASTE THERMOPLASTIC COMPOSITE FILM

**[1]Auwal . A.S.,[1] Gumel S. M., [2]Bashir U.G., [3]ALI. U., and [4]Bawa A.A.**
[1] Department of Pure and Industrial Chemistry, College of Natural and Pharmaceutical Sciences, Bayero University Kano, Kano State Nigeria.
[2] Jigawa State College of Remedial and Advanced Studies (JICORAS), Babura.
3 Sule Lamido University Kafin Hausa, Jigawa State, Nigeria
[4] College of Education and Preliminary Studies, Kano State Nigera.
Corresponding Author: Email auwaluabdulqadir442@gmail.com; Tel.:+2348066424121

***ABSTRACT***
***Natural fibres composite is the novel materials in recent decades having a high strength to weight ratio and light in weight, which are widely used for structural and unstructured applications. Jute fiber composite has several attractive advantages over synthetic and glass fiber Composite, like low processing cost, low density, stiffness and excellent mechanical properties. This advantage makes jute a very attractive reinforced fiber for composites and increased attention in construction, automotive, aerospace and many others. This paper is aimed at preparing environment Friendly Thermo plastic Film from Potato waste reinforced with Jute Fiber so as to improve its mechanical properties for packaging and Medical applications. The composite was prepared using hand lay up fabrication Technique. The composites were characterized using Fourier Transformed Infrared Spectroscopy (FTIR), Tensile strength tester, and physical characteristics of the composites (i.e. water absorption) were analyzed. Results of the FTIR shows an improvement in the physical and chemical characteristics of the composite, such as biocompatibility, due to hypsochromic shift in the absorption band of Jute fiber for the (OH, C=O, C=C and C-H) Functional groups from 3335cm$^{-1}$,2885, 1737, 1367 cm$^{-1}$ to 3270 cm$^{-1}$,2902, 1639, 1428 cm$^{-1}$ of the same functional groups in the plastic film Composite. Hence, plastic materials from potato waste was confirmed to be a promising material for packaging and medical applications.***
***Keywords: Jute Fibre, Composites, Mechanical Properties, potato waste starch Resin.***

## INTRODUCTION

Plastic is one of the materials used for households needs tools, packaging materials, construction and medical application however, the use of plastics is causing disastrous consequences to the environment (Tuty *et al.,* 2017). Why plastics are used everywhere despite their disastrous effects to the environment is due to their easy availability, cheap in the market value and perdurable (Arifa *et al.,* 2015). It has been postulated that one of the most grievous problems that our planet is facing today is the upheaval generated by excessive and impetuous use of single use plastics. Plastics like polyethene, Poly ethyleneterephthalate, polyvinyl chloride, and polystyrene, are synthetic polymers that are widely used in our day to day life owing to their stability, malleability and durability. The detrimental consequences of plastic pollution on the environment are widespread and noticeable and they include hormonal disturbances, developmental issues, cancer, and immunocompromised conditions (Nancy *et al.,* 2021). Thus, the world needs to fund a solution that may mitigate the danger of plastics and at the same time to access to miraculous ecofriendly alternative. Bio based plastics are the best candidate in this regards. Bio based plastics are polymers of biological materials. Biodegradability is an inherent property of any material that undergo degradation on exposure to microbes. However, not all biodegradable plastics are necessarily bio based, because certain polymers like polybutylene adipate therephthalate (PAT) and poly caprolactone are derived from fossil fuels and are biodegradable; similarly not all bio based materials are necessarily biodegradable. Hence bio based plastics are plastics which are derived from natural polymers present in biotic systems or chemically synthesized from polymers present in biotic system and decomposed and degrade naturally (Nancy *et al.,* 2021). Polysaccharides being the most abundant macromolecules in flora and fauna is one of the most suitable and promising bioplastics in the form of starch which is not only renewable and suitable, but also plentiful and cheap with favourable thermoplastic properties and biodegradable (Arifa *et al.,* 2015). However, starch-based bioplastic has some drawback of low physical properties, brittleness, low resistance to water due to hydrophilic properties of starch.

To improve this deficiency, is to add plasticizers. Plasticizers can be found in different forms such as sorbitol, glycerol, urea, fructose sucros and or glycol. However the most commonly used plasticizers are from the polyol group, namely glycerol and sorbitol.

A comprehensive research by Diyana *et al* (2021) reported effective utilization of four different types of plasticizer namely, glycerol, 1-ethyl-4-methylimidazohium acetate, sorbitol and triethyleneglycol at concentrations of 30%, 40% w/w in the starch mixture.

The resultant thermoplastic film formed was transparent, homogenous and flexible. To further improve the mechanical properties of the potato waste starch plastics is to reinforce the resin mixture with a fibre of natural origin. The use of natural fibres as reinforcement in the manufacturing of composites provides an excellent incentives for the productive use of agriculture waste (Shehu *et al.,* 2017. Fibre-reinforced plastic composites have long enjoyed the leading role with their high relative strength and modulus in a range of applications due to their versatility, lightness and simplicity of producing complicated shapes with economical savings as compared to fibre-reinforced metal/alloys integrated plastics (Mahfuza *et al.,* 2022). Hence, natural fibre-reinforced composites can effectively substitute conventional composites in different fields such as building and construction industries, transport and consumer goods (Gumel *et al.,* 2018). Natural fibre reinforced composites have gain considerable advantages over synthetic fibres in terms of good relative mechanical properties such as tensile modulus, and flexural modulus, improved surface finished of molded parts minimal health hazards (Ukanah *et al.,* 2018).

Natural fibres can generally be grouped into bast (jute, flax, hamp, kenaf) leaf (pineapple, sisal, henequen, screw pine,) and seed or fruit fibres (coir, cotton, oil palm).

In general, jute fibers are the principal load carrying member, while the surrounding matrix keeps them in the desired location and orientation, acts as a load transfer medium between them, and protects them from environmental damages due to elevated temperature and humidity. The aim of the study is to prepare an environment Friendly Thermo Plastic Film Composite from Potato waste Reinforced with Jute Fiber for improving its mechanical Properties.

## MATERIALS AND METHODS

### Materials

The potato waste used for the production of starch was obtained from a local potato vendor at Kabuga Dala local Government, Kano State. While the Jute fibre was obtained the plant at Dan Zaki Village, Gezawa Local Government Kano State.

**Chemical Reagents:** Chemicals used in this research includes HCl, (Sigma Aldrich) were procured from Polymer Chemistry Laboratory, Bayero University Kano. All other chemicals used were analytical reagents grade; they include ethanol, glycerol, sorbitol, THF, ammonium oxalate.

### Equipment

In addition to laboratory glass wares, instruments used in this research includes; Fourier Transformed Infrared Spectroscopy (Carry 630), Incubator shaker (Innova 4000), Hot air oven, Scanning Electron Microscope (SEM) and Tensile Tester.

### Preparation of Sweet Potato Peel Starch

To prepare sweet potato peel starch, 500g of the dried potato peel was crushed and powdered to obtain the fine powder by sieving through a 250$\mu$m mesh.

200g of the fine powder was mixed with 600ml of water and stirred for 10 minutes to obtain the starch suspension. The mixture was allowed to settle for 3 hours. Then, the fine starch was separated from the liquid by decanting the water part gently. The solid part was then oven dried at 50°C for 72 hours. The dried fine powder was stored in an airtight container before use.

### Preparation of Thermoplastics

Green thermoplastic composites were prepared using the formulations in table 1.

Table 1: Formulation ingredients in the production of green thermoplastics

| Material | Treatment | | | | |
|---|---|---|---|---|---|
| | A | B | C | D | E |
| Jute fiber (g) | 0 | 1.0 | 1.5 | 2.0 | 2.5 |
| Potato peel starch (g) | 10 | 10 | 10 | 10 | 10 |
| Glycerol (ml) | (2, 4) | (2, 4) | (2, 4) | (2, 4) | (2, 4) |
| 5% HCl solution (ml) | 2 | 2 | 2 | 2 | 2 |
| Distilled water (ml) | 100 | 100 | 100 | 100 | 100 |

Green thermoplastic reinforced with Jute fibers at different masses (0, 1, 1.5,2.0 & 2.5)g of the filler were synthesized. Potato peel starch was used as the matrix at constant mass of 10g for each film. Glycerol was used at two different quantity of 2ml/mixture and 4ml/mixture respectively to serve as plasticizer in the filmogenic solution to increase the plasticity and flexibility of the film.

While the Jute fiber was used as a filler in the film forming reaction at (2 & 4) g per batch of the preparation. Hence the green thermoplastic films were prepared by measuring 100ml of distilled water in a 1 litre beaker, 10g of the potato peel powder was added to the beaker and the mixture was stirred with a glass rod. The mixture was heated to about 120°C until the gelation of the starch was achieved. The starch solution was allowed to cool, after cooling, 3ml of glycerol, 5ml of 0.1M HCl were added to the mixture and stirred with a glass rod the mixture was then, heated at 70°C for 15min until the mixture became transparent. 2g of long Jute fibres was laid on the casting mould lined with a foil paper. The mixture was poured in the mould containing the jute sheath and allowed to cool at room temperature for 3-days. The thermoplastic film jute fiber composite was then baked at 18°C for 15 minutes and then allowed to cool at room temperature for 24 hours. The thermoplastic film was removed from the aluminum foil and packed in a glass container. The procedure was repeated using (Glycerol = 3, 5 ml, jute fiber = 2, 4g) for each film. Thus, 5 sample were prepared and characterized.

## CHARACTERIZATION

### Thickness measurement of the film;

The thicknesses of the thermoplastic composites were measured using a micrometer screw gauge at five different positions of the films. Thus the thickness measured from the average of the five measurements.

### Tensile test

Universal testing machine was used to measure the tensile strength of the sample, with 10mm/min as crosshead speed, 40mm length & 15mm width in this process each of the test samples was clamped on universal tensile testing machine and puled at a constant speed and maximum load of 5kg. From the results, tensile strength can be calculated using equation (1).

$\sigma$ = F maks/ A equation (1)

where,

$\sigma$ = Tensile strength (MPa)

F maks = maximum force (N)

A = cross – sectional area ($mm^2$)

### Elongation at break.

Elongation to break can be determined using equation (2)

% E = DL/Lo Equation (2)

where,

% E = Elongation to break (%)

DL = aceration of specimen length (mm)

Lo = initial length of the specimen

### Thermal Properties

The melting point of the composite materials was assessed by using oven heated at a temperature variation of 100 – 250°C. The sample to be tested were cut 2 × 2 cm and placed in the oven for 10 minutes and the observation recorded accordingly.

## RESULTS AND DISCUSSION

Physico-chemical properties of potato waste thermoplastic reinforced with jute fiber composite film.

What was the yield of potato peel starch?

**Table 2:** Fourier Transform infrared spectroscopy of jute fiber

| Jute fiber | Functional group/Frequency ($cm^{-1}$) | | | | | |
|---|---|---|---|---|---|---|
| Unmodified Jute Fiber | 3335 | 2885 | 1737 | 1596 | 1367 | 665 |
| Mercerized Jute Fiber | 3481 | 2885 | 1737 | 1594 | 1367 | 672 |
| Potato waste plastic | 3270 | 2902 | 1639 | 1592 | 1428 | 670 |

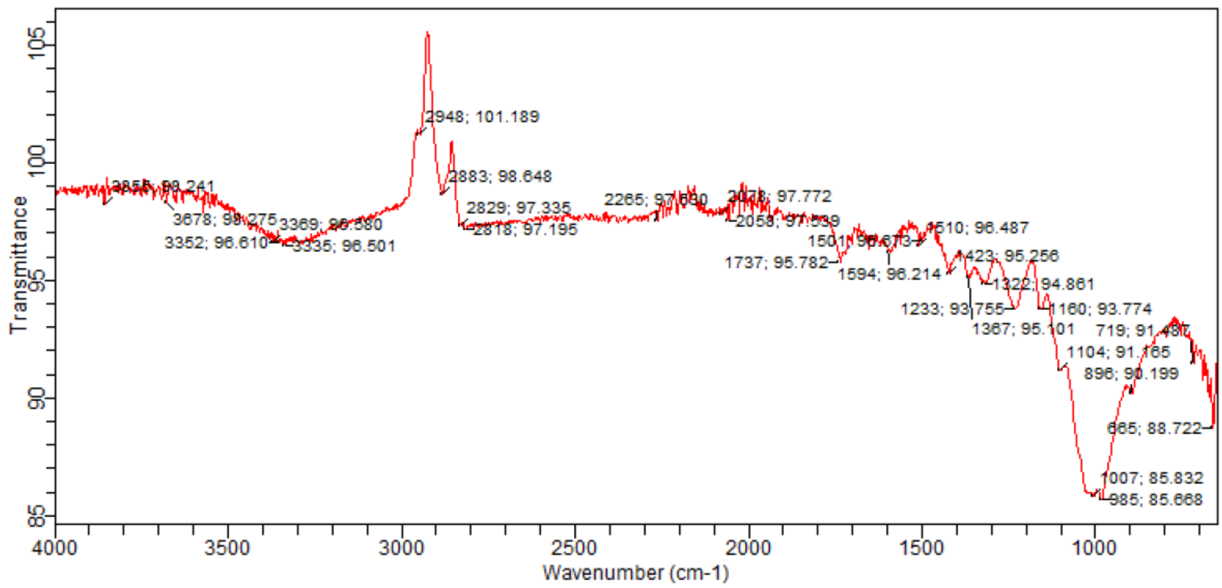


**Figure 1: FT-IR spectra for Unmodified Jute Fiber**

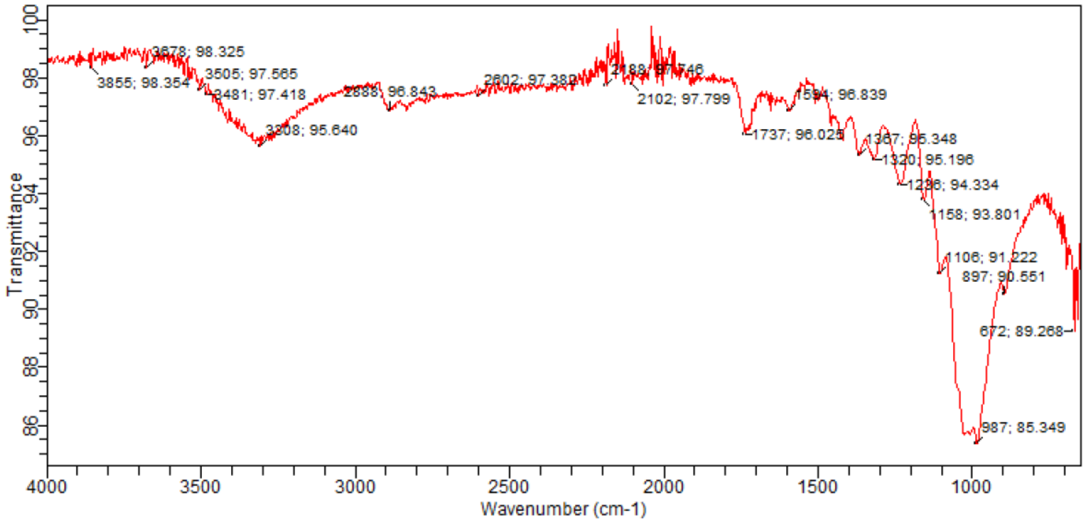


**Figure 2: FT-IR spectra Alkaline Modified Jute Fiber**

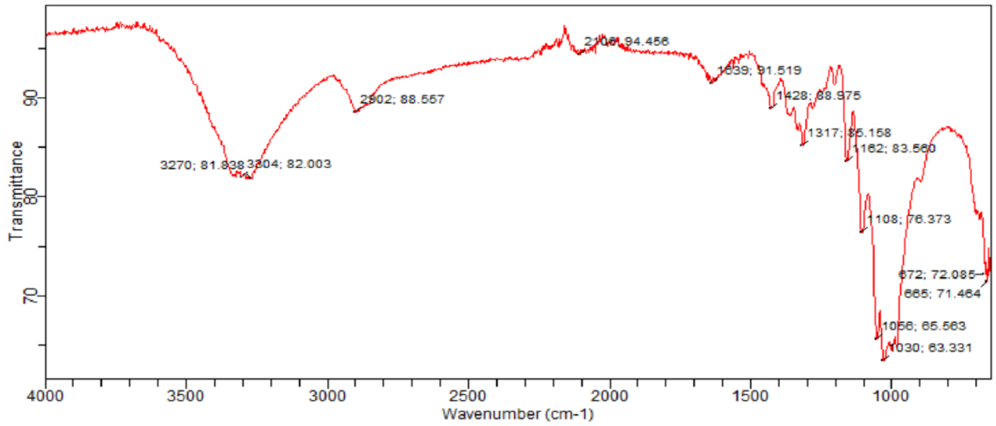


**Figure 3: FTIR Spectrum of Potato waste plastic.**

**Thickness of the film**

The thickness of all the samples measured with micrometer screw gauge shows that the thickness was in the range of 0.109 to 0.140 mm. The results of the average thickness is depicted in table 3. It was observed that increase in jute fiber, increases the thickness of the composites.

**Table 3:** Average value of thickness of the thermoplastic composites

| Samples | Thickness (mm) Mean±Standard deviation |
|---|---|
| 0 (g) jute | 0.109±0.0005a |
| 1.0 (g) jute fiber | 0.113±0.0041a |
| 1.5%(g) jute fiber | 0.125±0.0022a |
| 2% (g) jute fiber | 0.129±0.020b |
| 2.5%(g) jute fiber | 0.140±0.020c |

From table 4, it was observed that the amount of jute fiber has great influence in the mechanical properties of the thermoplastic jute fiber reinforce composites. It was shown that water absorption of composite increases with increase in the amount of the fiber in the composite. This is due to the increase in hydrophilicity of the composite. This results is in agreement that obtained by Tuty *et al* (2017) who reported that varying the amount (%) of the filler in a starch or bioplastic composite led an increase in water absorption of the composites. Hence the higher the amount of jute fiber, the higher the water absorption.

**Table 4:** Effects of fibre dosing on the mechanical properties of the composites.

| Sample | Water absorption (%) | Transparency (%) | Tensile strength (Mpa) | Elongation to break (Mpa) |
|---|---|---|---|---|
| Thermo+0% jute fiber | 120.92 | 68.86 | 25.92 | 1.72 |
| Thermo+1%jute fiber | 138.39 | 63.20 | 32.30 | 1.40 |
| Thermo+1.5% jute fiber | 162.86 | 57.92 | 39.86 | 0.89 |
| Thermo+2% jute fiber | 185.63 | 49.57 | 44.20 | 0.69 |
| Thermo+2.5% jute fiber | 220.22 | 43.74 | 47.96 | 0.34 |

On the other hand, the tensile strength of thermoplastic composites reinforced with jute fibre was greatly affected. These results in conformity with Neha *et al.* (2021) who repot similar results of the study conducted on potato starched based biodegradable packaging film. While elongation at break follow the same trend as increase in the fiber dosing lead to decrease in the value of elongation to break. The results have shown that highest value of elongation was with the addition of 0% jute fiber. The elongation was 1.72 MPa and the lowest was by the addition of 2.5% jute, recorded a value of 0.34 MPa. This result is in agreement with Norhafezah and Mohammad (2018) who reported a similar results from their study on the enhancement of Bio-plastic using eggshells and chitosan on potato starch based. Conversely, the transparently of the composite decreases with increasing fiber content as depicted in table 3. This was related to the increase in the thickness of composite by the addition of the fiber in quantity dependent of the fiber. A similar result was reported by Neha *et al* (2021).

Effects of fibre loading on the mechanical properties of chitosan – modified potato waste thermoplastic composites reinforced with a baobab fibre.

**Thermal properties**

The melting temperature of the composite was strongly affected by the jute fibre dosing. It was established that increasing in heating temperature not only affect the appearance of thermoplastic but also affect the mechanical properties of the composites. Increase in temperature led to britillity of the composite and hence easily broken. It was thus concluded that high heating temperature affect the structure of bio plastics as reported by Tuty *et al.* (2017).

## CONCLUSION

In this study effects of using Jute fiber as reinforcement in the synthesis of bio-thermoplastic composite for packaging applications have been investigated. However, the mechanical properties of the composites was enhanced by the addition of the jute fibre. From the results it was observed that samples with high fibre content (2.5g) exhibit the highest tensile properties with least elongation at break values. Hence, potato waste can now be considered as a potential substrate in production of a durable thermoplastic packaging materials especially when reinforced with a potential natural fibre from Jute plant. Therefore this study suggest the economic importance of waste materials in the control of environmental pollution and cost reduction of packaging materials.

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