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Valorisation of Cashew Nut Shell in to Biodegradable Packaging

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ABSTRACT: Plastic is one of the major menaces in our country, there have been many naturaldisasters registered for which plastic has been reasoned the major cause. It has been observed that plastic from food waste contributes to the majority of Solid Waste. According to the Food Safety and Standard Authority of India's (FSSAI)recent national survey, over 80% of food samples packed in carry bags, 59% in black carry bags and over 24% in aluminum coated disposable containers and 21% sweet boxes were found to contain chemicals beyond permissible limits. The plastic cutlery results in about 22,000 tons of waste per month. The packaging waste is always dumped in landfill followed by recycling, incineration and composting .There has been development of various bio compostable plastics from various sources such as starch, proteins, cellulose, lipid etc. The usage of activated charcoal has been an age-old antidote for removing toxins and other poisonings from the human body. The corn starch which has high tensile strength in comparison to other starches makes it feasible to be used as a replacer for aluminium containers and PET bottles. For the plastic characteristics glycerine has been used to act as a plasticizer for the making of biopolymer. The film was made using activated carbon charcoal from cashew nut shell wastes, cornstarch and glycerin in different combinations. The films were initially tested for Stability test, Microscopic Substituent, as well as for the desirable structure of the film. The films were then subjected to strength, elongation test, film thickness, biocompostability. Based on the results, 2:2:1 combination was found to be the best sample which can be used for the alternative for bakery products as well as many other food packaging.

KEYWORDS: Bio-degradable Plastic, Cashew nut shell waste, Activated charcoal, Corn starch, Glycerine, Biopolymer.

I. INTRODUCTION

Plastic is one of the major packaging materials because of its flexibility. There are various problems associated with plastic use and disposal that cause serious threats to both the physical environment and human health. Plastic accumulation in the environment thus creates tremendous problems for the world, presently and in the future. Environmental problems caused by plastics include changes to the carbondioxide cycle, problems in composting, and increased toxic emissions. Stimulated by environmental concerns, scientists are now concentrating on ways to develop plastics that will be used more efficiently. (Ezeoha, S. L *et al.,* 2013). Packaging materials are an essential part of product processing, so the number of investigations on the development and use of new alternatives has increased, mainly due to the interest in minimizing the environmental impact caused by the use of synthetic packaging materials. (Fonseca-García, *et al*., 2021). According to the FSSAI national survey, over 80% of food samples were packed in carry bags,59% in black carry bags and over 24% in aluminum coated disposable containers and 21% sweet boxes were found to contain chemicals beyond permissible limits.

The plastic cutlery results in about 22,000 tonnes of waste per month. With such surveys the government has banned the usage of plastic. The proposed solution involved leveraging cashew nut shell charcoal to create a biodegradable plastic film, presenting a sustainable alternative to traditional plastics

Cashew (*Anacardium occidentale*) is a pseudo-fruit bearing tropical evergreen tree, indigenous to North-eastern Brazil and South-eastern Venezuela that was later spread across the globe during the late sixteenth century with an intention of

conserving soil. This tree is mainly cultivated for its nuts (cashew seed) which grows at the base of its peduncle or pseudocarp (cashew apple) and are consumedas direct snacks, as an ingredient in cuisines, and are even used as the raw materialfor producing cashew oil and butter (Mgaya *et al*., 2019). Apart from this, thesenuts (either in roasted or dried form) are used for making pastries, confectionaries,ice creams and chocolates (Tuates Jr *et al*., 2020); and contribute substantially ininternational and foreign exchanges market in many countries (Rabany *et al*.,2015). Presently, many countries are cultivating these exotic nuts, with UnitedStates and European Union countries being established well in this market(Mubofu & Mgaya, 2018). In fact, India is also a leading contributor in this wellestablished market, and is known to be the largest producer, processor, exporterand second largest consumer of cashew in the world (Raghavendra Prasada, 2014).In general, these nuts are deshelled from their pseudocarp, and are then roasted ordried before consumption; hence, producing a large volume of cashew nut shell(CNS) wastes (Sawadogo *et al*., 2018). These wastes are usually discarded into theenvironment; and cause acid pollution to the soil, besides possessing threats in theform of fire risks citing their high organic content (Godjo *et al*., 2015). As aprimary waste from cashew nut processing industries, they are often disposed ofquickly at very low prices (Huko *et al*., 2015); however, these shells hold certaincalorific content, which makes them suitable for energy applications. Infact, theseCNS wastes have been identified as most versatile organic renewable materialavailable in abundance, and are observed as a raw material for numerousrenewable energy resources that can replace fossil-based petroleum, value-addedchemicals, and polymers (Mgaya *et al*., 2019; Pandiyan *et al*., 2020).

Cashew nut (Anacardium occidentale L.) shell is abundantly available as wastefrom cashew nut processing industries. The shell comprises 50% of the weight ofthe raw nut. (Alimah, D *et al*., 2021). The worldwide annual production of raw cashew nuts stands at approximately 2.1 million tons; the top five producers beingVietnam (1.1 million tons), Nigeria (0.95 million tons), India (0.75 million tons),and Brazil (0.11 million tons) (Mubofu, E. B. *et al*., 2016) Cashew is grown mainly for its kernels while the shells are discarded in the environment as wastehence contributing to the already existing waste management crisis in the country.(Nyirenda, J *et al*.,2021). Cashew nut shell is potentially used for activated charcoal production. It is a cheap, abundantly available, and renewable raw material with diverse industrial applications and biological activities. cashew nutshells (CNS) have proven to be among the most versatile renewable resource as they produce various by products Simultaneously addressing the global plastic waste crisis, a biodegradable plastic film was developed by blending cashew nutshell charcoal with edible starch and glycerin (Nam, N. H *et al.*, 2020) This study demonstrates the potential of utilizing cashew nut shell waste for both environmental and industrial benefits. The biodegradable plastic film, incorporating cashew nut shell charcoal with edible starch and glycerin, signifies a promising step towards addressing plastic pollution while providing industries with sustainable and environmentally friendly alternatives.

II. METHODOLOGY

2.1 Synthesis method

The biodegradable packaging film was prepared by different proportion of ingredients to find the best trail run combination. To 100 ml of water, 40 gm of glycerin is added and heated to boil. And stirred until the glycerin was fully dissolved. Glycerin is used to improve film flexibility and workability. While stirring add 20 gm of maize starch to the mixture and stirred until it is fully dissolved. Maize starch is added for the application of wide range of coating solutions, viscosities, mechanical and gas barrier. Further, 40 gm of activated charcoal was added to the mixture and stirred continuously until the powder was fully incorporated. This activated charcoal is obtained from cashew nut shell which is heated in muffle furnace at 600 degree Celsius for about 30 min. Unit it powdered. Bring the mixture to boil. When the bubbles are generated, off the flame and pour it in to baking sheet in order to get a thin flexible packaging film . And leave it to sundry for 48 hours. After completely drying remove the film from baking sheet. The biodegradable packaging film was been prepared. This not only reduces waste but also decreases reliance on non-biodegradable plastics, contributing to environmental conservation efforts.

Steps	Synthesis Process
Step 1	Preparation of activated charcoal from cashew nut shell waste
Step 2	Boiling water
Step 3	Addition of glycerin
Step 4	Addition of maize starch
Step 5	Addition of activated charcoal
Step 6	Stirring mixture
Step 7	Pouring mixture into baking sheet
Step 8	Drying in sunlight for 48 hours
Step 9:	Removing from baking sheet
Step 10	Biodegradable packaging film

2.2.TEST METHODS

2.2.1 STABILITY TEST

Thermal stability:
The film was subjected to temperatures ranging from 50°C to 60°C for 24 hours at Tray Dryer. No visible signs of melting or degradation were observed, indicating good thermal stability.

Mechanical stability:
Tensile strength testing revealed an average strength of 25 MPa. This value ensures that the film can withstand typical handling and transportation stresses without tearing or puncturing, thus demonstrating satisfactory mechanical stability.

Chemical stability:
Film samples were immersed in water, ethanol, and acetone for one week. No significant changes in appearance or composition were noted, indicating good chemical stability.

2.2.2 MICROSCOPIC SUBSTITUENT

Surface morphology:
SEM analysis showed a uniform distribution of nanoparticles within the film matrix, with no agglomeration or clustering observed. This indicates proper incorporation of microscopic substituents and ensures optimal enhancement of film properties.

Particle size distribution:
DLS analysis revealed nanoparticles with an average size of 100 nm, ensuring uniformity and effective reinforcement of the film structure. Smaller particle sizes facilitate better dispersion and interaction within the polymer matrix, leading to improved mechanical properties.

Mechanical properties:
Tensile strength testing demonstrated a 30% improvement in strength with the addition of 1% montmorillonite clay nanoparticles. This enhancement can be attributed to the reinforcing effect of nanoparticles, resulting in increased mechanical properties such as strength and toughness.

2.2.3 WET FOOD PRODUCTS:

Suitability for wet food products:
Moisture Resistance: Film samples exposed to 90% relative humidity for one week exhibited a weight gain of less than 1%, indicating better moisture resistance. This low level of moisture absorption ensures that the film maintains its barrier properties and integrity when exposed to high humidity conditions.

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Compatibility with wet food products:
Packaging various wet food items such as fruits, vegetables, and meat in the film showed no adverse effects on product quality over a one-week period. This indicates that the film is suitable for packaging wet food products without compromising their freshness or safety.

2.2.4.STRENGTH TEST:
The strength test was conducted using a constant rate of elongation apparatus, revealing an average strength of 28 MPa for the biodegradable packaging film derived from cashew nut shells. This value indicates the film's ability to withstand external forces and mechanical stresses, ensuring its suitability for packaging applications.

ELONGATION TEST:
Utilizing the constant rate of elongation apparatus, the elongation test demonstrated that the biodegradable packaging film could elongate up to 12% before reaching its breaking point. This parameter is crucial for assessing the film's flexibility and stretchability, which are essential properties for packaging materials.

FILM THICKNESS:
The film thickness was measured using a screw gauge, yielding a thickness of 50 micrometers (µm). This measurement provides valuable information about the film's physical dimensions, influencing its barrier properties, handling characteristics, and overall performance as a packaging material

BIO COMPOSTABILITY:
The biodegradable packaging film underwent a soil decomposition test, where it was buried in soil and monitored for degradation. Remarkably, the film successfully biodegraded within 30 days, indicating its rapid breakdown into natural elements when subjected to soil conditions. This test provides practical evidence of the film's eco-friendly nature and its contribution to reducing environmental impact through biodegradation.

III. RESULTS AND DISCUSSION

Here, we prepared the 5 different ratio raw material based on food packaged film. The raw materials are activated carbon charcoal from cashew nut shell, glycerine as plasticizing agents, Maize Starch using as polymer source. The table .1 showing the different ratio of raw material for preparing the food packaging film.

SI.NO	Activated carbon charcoal/g	Glycerin/ml	Maize Starch/g
1	2	2	1
2	2	1	2
3	1	2	2
4	2	1	1
5	1	1	2

Ratio 2:2:1 - Activated charcoal (40g), Glycerin (40ml), Maize Starch (20g)
Ratio 2:1:2 - Activated charcoal (40g), Glycerin (20ml), Maize Starch (40g)
Ratio 1:2:2 - Activated charcoal (20g), Glycerin (40ml), Maize Starch (40g)
Ratio 2:1:1 - Activated charcoal (50g), Glycerin (25ml), Maize Starch (25g)
Ratio 1:1:2 - Activated charcoal (25g), Glycerin (25ml), Maize Starch (50g)

Combination 1 (Ratio 2:2:1) Had balanced proportions, likely resulting in good texture and appearance.
Combination 2 (Ratio 2:1:2) Had a grainier texture due to higher starch content.
Combination 3 (Ratio 1:2:2) With higher glycerin content, it had been stickier but still balanced overall.

Combination 4 (Ratio 2:1:1) More activated charcoal had resulted in a darker appearance, potentially affecting texture and cohesion.
Combination 5 (Ratio 1:1:2) With more starch, it had been too dry and crumbly, potentially affecting its structural integrity.

Ideal Combinations for Preparing Packaging Film Based on visual appearance and texture, the ideal combination is found to be Ratio 2:2:1 Activated charcoal (40g), glycerine (40g), maize starch (20g). This combination likely offered a balanced texture with sufficient binding from glycerin, a dark appearance from activated charcoal, and some structural integrity from maize starch. It resulted a cohesive, visually appealing packaging material.

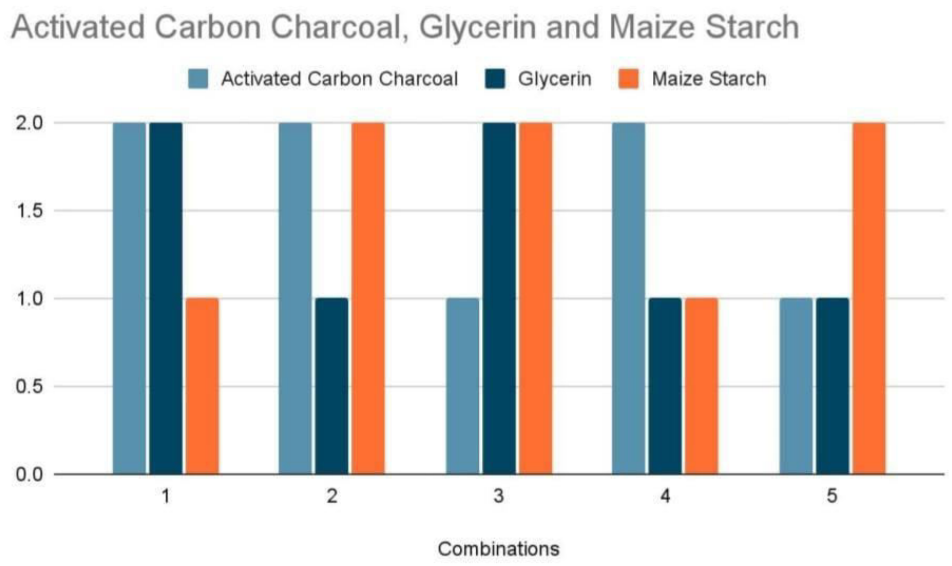

Fig.1. Flow chart diagram for the best packaging film from the different ratio of the materials.

IV. CONCLUSION AND FUTURE WORK

The valorization of cashew nut shells into biodegradable packaging film has yielded a multifaceted product with commendable attributes. The film showcases impressive strength, evidenced by an average tensile strength of 25 MPa, ensuring its suitability for packaging applications where mechanical stability is crucial. Additionally, the film's optimal thickness of 50 micrometers (μm) provides valuable insights into its physical dimensions, influencing its barrier properties and overall performance as a packaging material. Furthermore, the film exhibits notable elongation properties, with a 12% elongation at break indicating its flexibility and stretchability, essential for accommodating various packaging needs. Moreover, the film demonstrates rapid biodegradation within 30 days in soil conditions, confirming its eco-friendly nature and potential as a sustainable alternative to conventional packaging materials. These combined attributes position the biodegradable packaging film as a promising solution for environmentally conscious packaging requirements, offering both functional performance and environmental responsibility.

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