EDIBLE AND BIOCOMPOSTABLE PACKAGING FILM BASED ON ACTIVATED CHARCOAL FROM COCONUT SHELL WASTE

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ABSTRACT

Plastic is one of the major menaces in our country, there has been many natural disasters registered for which plastic has been reasoned the major cause. It has been observed that plastic from food waste contributes to the majority of the Solid Waste. The current survey done at national level in India by the Food Safety and Standard Authority (FSSAI) stated that over 21% of sweet boxes, aluminium containers have 24%, 80% carry bags and black coloured bags are 59% have non-permissible amount of plastics in them. 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 human body. The corn starch which has high tensile strength in comparison to other starches makes it feasible to be used as 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 coconut shell wastes, corn starch and glycerine in different combinations using 0,1,2 as levels for combination of the raw materials respectively. The films were initially tested for rehydration property as well as for the desirable structure of the film. The films were then subjected to physical, mechanical properties and shelf life testing of food. Based on the results, 1:2:2 combinations was found to be the best sample and was moulded in the form of pouches to eliminate the direct contact food packaging which can be used for the alternative for bakery products as well as many other food packaging.

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INTRODUCTION

Plastics have gained as a vital and wanted packaging source to wrap and store almost all the material starting from food, chemicals, beverages and so on. Plastics are widely preferred as they have high tensile strength, light in weight to carry them in palms, have stretch ability, and are highly sealed and durable are some of the pros of plastics when compared to other packaging materials that are available**(Rudnik, 2013)**. In India, annual report from Central Pollution Control Board's (CPCB) 2019-2020 estimates that around 3,360,043 tonnes per year that is about 9,200 tonnes per day of the waste that is only plastic was produced. The plastic waste amount generated is quite high and causes severe environmental issues. Organic molecules consisting of many repeating units linked together to produce long chain molecule with high molecular weight in the range of 5000 - 100,000, which are hard to be degraded by the microorganisms that are living in the natural environment is how commonly plastics are made**(Rudnik, 2013)**. For degradation to take place the strong carbon bonds needs to be broken and for plastics that are dumped in landfills it takes upto 1000 years to decompose entirely**(C. C., 2013)**. Than the scarcity of the water the impurity of water, the dumping of plastic and waste in to water bodies has become a major concern around the globe, as the NEWS goes in and out of serious health risk and possible risk in water conservation from all around the globe, from California to India there are huge concern.A landfill poses a major issue, as they affect wildlife and ground water through pollutant penetration underground resulting in degradation of the water quality. The water bodies particularly ocean is accumulated with 18 million pounds of plastics. Higher order organisms in the marine ecosystem and other small organism intake the plastic without knowing it, these plastics are converted into microplastics which are further hard for degradation affecting the food chain of both small and large organisms. It means that plastic is ingested by many people every day (Albuquerque et al., 2018). Landfills are one of the common ways to discard the plastic waste. When they are in the landfills there is not only one type of chemicals but all the slurry and other waste deposits cause harmful chemical reaction that affect the ecological balance **(Elanchezhian et al., 2018).**When the plastic is incinerated in the open environment there is a out go of chemicals that are released and when they enter into the respiratory tract they cause lung disorders, difficulty in breathing and other diseases.The plastics manufactured artificially using number of toxic chemicals will also pose major concern in storing, disposing and contaminating the packaged materials can be extremely harmful to living things **(Anjum et al., 2016).** The removal of these plastic disposals itself costs several dollars. Hence this project aims to replace this issue with compostable packaging films which may not spend much time as landfills. Based on the review, corn starch is used in preparing the compostable packing film suitable for packing dry, semi-dry and moist foods without deteriorating the shelf life of foods.

MATERIALS AND METHODS

Sample Preparation

Preparation of Activated Charcoal

There are many raw materials and sources for the activated carbon preparation. Some of them are paddy husk, coir pith, coconut shell and so on. These carbonaceous materials are used to produce the non-graphite form of carbon known as the activated carbon **(Karacan et al., 2007)**. Of all these sources coconut shell has excellent properties for the activated carbon production because they are able to deliver gas or vapour for better adsorption and this is because of their small macrospore structure, they also have better properties for the removal of colour and odour.Gas grade adsorption of carbon is superior using coconut shell shows literature. In a muffle furnace at controlled temperature of about 900°C - 1100°C coconut shell is activated with steam**(Gao et al., 2013)**. Muffle furnace or muffle oven is an instrument that separates the content that needed to be heated from all the extra products including vapour and ash. They separately heat only the material.

The coconut shell was first broken into small piece. The small pieces were then kept inside the muffle oven at a temperature of 600 °C. By following this procedure activated carbon from charcoal was produced. They have advantages when compared to other form of production. They are able to remove toxin from body, can bring high cholesterol levels down and can help to increase the bone strength. The quantity of charcoal that was used is 20gram/day as per FDA norms.

Preparation of polymer film

When starch is heated with vinegar it helps in making a film by transforming starch in to a polymer. The acetic acid that is present in the vinegar breaks the crosslinking of amylopectin as a result only amylose chain is left. This amylose then forms a cohesive force

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with the activated carbon from coconut shell and glycerin that act as a plasticizer and forms a film together. Hence high level of starch is used with the edible film to avoid mis-consumptions. The compostable packaging film comprises of the chemicals namely cornstarch, 25% of acetic acid, and 95% of glycerol.Biopolymer fabrication was carried out by mixing cornstarch with glycerol and activated charcoal with a composition ratio of 2:2:1**(Laine et al., 1989)**. To 25% of acetic acid the mixture was added. With the help of an induction stove the obtained mixture was heated at 100°C for 20 minutes before which homogenization of the mixture was manually carried out. Viscous product was obtained after this. The obtained product that is viscous was then dried after molding. It was dried at ambience temperature for about a day or two and a solid white film was obtained. The permissible level of glycerin and corn starch suggested for consumption by FDA was used.

Activated charcoal, maize starch and glycerin were added with different combinations mostly 27ratios of all the three produced materials are used. They are then heated at a temperature of about 100°C until the mixture finally comes to a boil. The bubbles were then allowed to settle down. Once they are settled and dried the edible biofilm is obtained. The film was then subjected to test the mechanical properties such as tensile strength, Young's modulus and elongation at break. The thickness of the film was determined using screw gauge a biodegradable test results were analyzed by keeping them in open environment to see how the environmental flora and fauna decomposes the edible package.

Mechanical properties

The film sample that was obtained was tested to know their mechanical properties and study the mechanical strength. 5 × 5 mm was the size to which the film was cut for the study.Different thickness of the sample sliced was tested to make sure that the measurement is dependable. To know the mechanical strength and property of the obtained cut film it was subjected to know the tensile strength and hardness **(Sherwani et al., 2021).**Zwick/Roell Testing Machine with 2 kg/min of crosshead speed with a cell load of 50kN was performed to know the tensile property.Mitutoyo Shore D hardness tester was used to know the hardness and hardness shore D test was used for this. The thickness of the film was spotted using ASTM D 1777-96 as base.

Tensile strength:

Tensile strength is the maximum amount of force that the material can hold when it was pulled or stretched until the material is fractured. Tensile strength is calculated using the equation **(Tanoto et al., 2017)**

Tensile strength $= F_M / A_0$ 1

In the above equation F_M = maximum strength (N), A_0 = cross sectional area of the material (mm^2) and MPa = tensile strength of the unit.

Elongation at break

Elongation at break is the flexibility of the material, which is how far the material is stretchable or extended after the fracture in tensile strength. It was determined using the equation,**(Tanoto et al., 2017)**

Elongation at break $= (L - L_0)/L \times 100$ 2

L is the elongation of the material at final stage (mm), L_0 is the material elongation at initial stage (mm).

Young's modulus

Young's modulus analyzes the stiffness of the material to deformation of elasticity after load is applied. Young's modulus (MPa) was analyzed using the equation below, **(Tanoto et al., 2017)**

$$\text{Young's modulus} = (\sigma 2 - \sigma 1)/(\varepsilon 2 - \varepsilon 1) \quad 3$$

$\varepsilon 1$ *and* $\varepsilon 2$ are relative elongation conditions at 0.05 and 0.25%, $\sigma 1$ *and* $\sigma 2$ are the stress occurring at $\varepsilon 1$ and $\varepsilon 2$. The unit for Young's modulus is MPa.

Biodegradability:

Water, carbon dioxide and inorganic compounds that are not toxic are released during biodegradation process **(Souza et al., 2013)**. The biodegradability tests were conducted by slicing the prepared biopolymer with sizes of about 5 × 5 mm and then the film was placed in a soil and checked after three days of time interval. There was a decrease in the size of the film and was subjected to microbial testing for the presence of bacteria **(Kundu &Payal, 2022).**

RESULTS AND DISCUSSION

Sample Preparation

Preparation of Activated Charcoal

The coconut shell wastes were collected and heated at the temperature of 600ºC and the activated charcoal powder was obtained as shown in the figure.1.

The extraction of activated carbon was made by using coconut shell as the raw material and the muffle furnace was used in this experiment. The coconut shells were broken into small pieces so that it can be suitable to be placed inside the muffle furnace. The temperature maintained in the furnace was 600 ºC. Then the activated charcoal powder was produced from the furnace.

Figure.1. collected coconut shell waste heating at 600 ºC and activated charcoal was produced

Preparation of polymer or film

The corn starch was combined with obtained activated charcoal and glycerin to get the polymer film. The mixture was heated at the temperature of 100 degrees Celsius to combine all the mixtures and forming the film. Since all the mixtures have separate properties they needed to be heated to get it mixed and form the film.

Figure.2. Shows a) the combination of corn starch, and b) combination of activated charcoal, corn starch and glycerin,c) formed film.

Edible pouch preparation

The poach sealer was used for sealing the sides of the polymer film and making the edible pouch. The edible film was placed and shaped like the bag or pouch and sealed the openings with the help of pouch sealer to make it an edible pouch or bag.

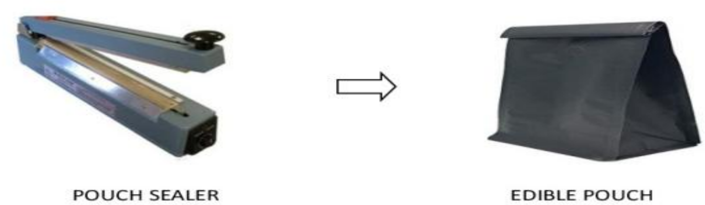

Figure.3. a) Pouch sealer used for sealing the pouch b) the edible pouch obtained.

Mechanical properties

Tensile strength

The tensile strength of the obtained film sample was measured with the help of Zwick / roell instrument. Here the tensile strength experiment was done for determining the strength and deformation behavior of the obtained film till point of fracture. The elongation percent was also obtained from the above mentioned instrument. The strength (N) of the film obtained was 38.6 and the percentage of elongation was 5.4%. This shows that the film has the capacity to hold the food products and can be used for the food packaging process.

Table.1. the tensile strength of the packing film sample with strength and elongation%

FILM – TENSILE STRENGTH (ZWICK/ROELL)	**C1800802-1 PACKAGING FILM SAMPLE**
STRENGTH (N)	38.6
ELONGATION %	5.4

Thickness

The thickness of the film was calculated according to the ASTM D 1777-96 method. This method is a standard method for the calculation of thickness of a material. The thickness was measured in millimeter and the thickness of the obtained sample was 0.98 mm. The obtained thickness can be used in the food packaging process since the film with the above mentioned thickness can hold the food materials without any mishap.

Table.2. the thickness of the sample

FILM – THICKNESS (As per ASTM D 1777-96)	C1800802-1 PACKAGING FILM SAMPLE
THICKNESS (mm)	0.98

SHELF LIFE TESTING

The shelf life of the food productswere tested by using the edible pouch prepared. The intermediate moisture foods (biscuits) and fired food products (chips) were placed in the pouch and the shelf life was checked.

Table.3. the types of food items and shelf life of packed food products

FOOD ITEMS	SHELF LIFE OF PACKED FOOD PRODUCTS
Chips	21 days
Biscuit	35 days

The intermediate moisture food that was biscuits has the shelf life when packed in the produced edible pouch as 35 days where as the fired food products that was chips that have the shelf life of 21 days in the edible pouch. The table given below has given a detailed account on the shelf life obtained in the edible pouch for two different food products.

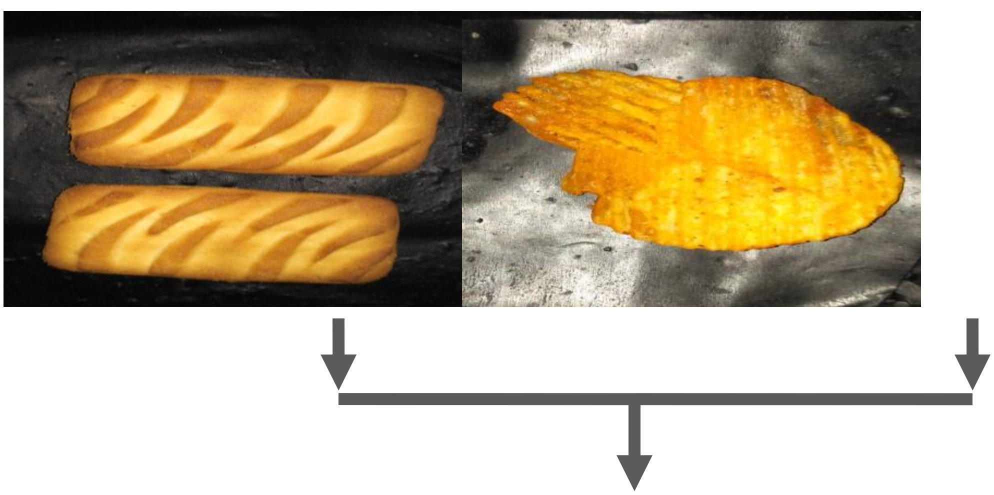

Figure.4. Food products packed in the edible pouch

Biodegradability

The biodegradability of the prepared film was tested by using the soil burial method. The film was analysed for its size (15x4mm), biodegradability efficiency and the presence of microorganisms before and after burying in the soil.

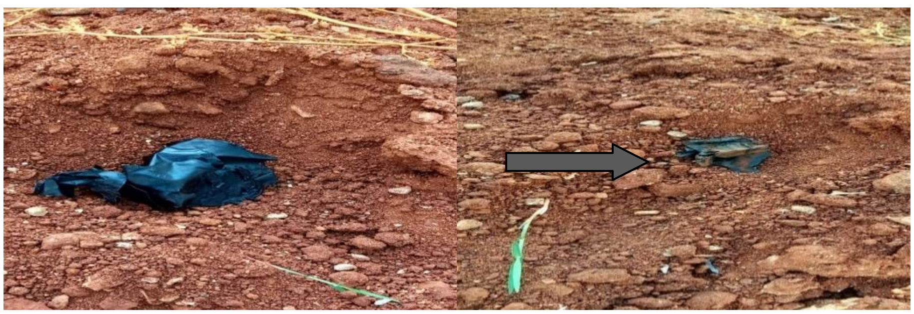

Figure.5. a) Edible pouch placed in soil initially, b) edible pouch after 15 days in soil

After burying for three days they were checked for its biodegradability effect and it has been confirmed that the size of the film has been reduced from its initial size and the presence of microbes was positive on the film, here the presence of bacteria was identified. The film has been reduced to its $1/4^{th}$ from the initial stage when buried for 15 days.

CONCLUSION

In this study we can conclude that the usage of activated charcoal for the preparation of edible pouch for storing the foods in the food packaging technology. These edible pouches are consumable and it has been made by using muffle furnace method where the extra products will be excluded and only the material that is needed will be heated. So we will get pure component that are consumable as the end product. Starch and glycerine were also added which can also be considered to be consumable materials. The edible pouch is a polymer film that can be used as a alternative for plastic introducing the environmental pollution. The mechanical properties of the edible pouch has been analysed they are tensile strength, thickness, elongation percent and so on. The shelf life testing has also been carried off by using two types of food products such as intermediate moisture food and fried food. Biodegradability test is also being carried out to check the degradation of the bio plastic that has been produced and it is prove that this edible pouch can be degraded with the help of microorganisms such as bacteria within less than 15 days. Hence the usage of this edible pouch that is a bioplastic can be an excellent replacement for the conventional plastics.

Conflict of Interest

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