



Bioplastic from Chicken Feather Waste

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ABSTRACT

Plastics are typically polymers of high molecular weight and one of the chemical materials which cause severe environmental problems. Improper disposal of plastic bags blocks the porosity of the soil and causes problems for groundwater recharge. Due to its non-biodegradable nature, littering of plastics causes irreversible damage to the environment. As increasing plastic waste threatens ecological sustainability the only solution to this is developing of bio-degradable plastic, that too from the waste. The feather is highly micro crystalline, very durable and resistant to both mechanical and thermal stress because of the presence of protein Keratin. They are proved to be stronger than wood. Its value is similar to polypropylene. Feathers comprise over 90% of proteins the main component being beta keratin, a fibrous insoluble protein containing disulfide bonds. These bonds provide resistant to digestion by the proteases of animals which are the major disposal problem for degradation of feather waste. Keratinase is the enzyme which is used to degrade feather waste and in the production of animal feed, fertilizers. The present study screened for the ability to hydrolyze keratin in feather meal broth. Keratinase activity of *Bacillus Subtilis* maximum concentration was 1.23 (IU/mL on 7 days respectively). The objectives are to increase the biodegradability of conventional biodegradable plastic and to utilize the chicken feather waste effectively.

Keywords: Keratin, feathers, fibrous, biocomposites, keratinolytic activity.

INTRODUCTION

As increasing plastic waste threatens ecological sustainability only solution to this is developing of bio-degradable plastic that too from the waste. Biodegradable plastic made from biological materials which meets the need of keeping the advantages of conventional plastics by keeping away the harmful and serious environmental effects of it. Conventional plastics provide functionality that cannot be easily or economically replaced by other materials. Most of the plastics and plastic containing materials last for thousands of years, now the bioplastic and are cheaper, lighter, safer, stronger and easier to recycle¹.

Chicken feathers are waste products of the poultry industry. Billions of kilograms of waste feathers are generated each year by poultry processing plants, creating a serious solid waste problem^{2,3}. The major waste product that is abundantly discarded from any poultry farm is chicken feathers. 8 billion-plus broilers produced each year by the U.S. poultry industry leave behind some 4 billion pounds of waste feathers. Keratin from chicken feathers is a by-product which is available in great amounts that can be used in the production of bio fuels and bio plastics.

The idea of using waste chicken feathers for the production of eco-friendly plastic is a novel one. The best part is that this inexpensive source is available in plenty. What makes chicken feathers ideal is that they are rich in keratin, a tough protein. As compared to other biological sources like plant proteins and modified starch, keratin-based plastic offer greater strength and are tear-resistant.

The biggest plus, of course, is that unlike most petroleum-based thermoplastics, feather-based plastic doesn't depend on any fossil fuels.

This bio-plastic can thus be used for making everything from cups, plates to furniture. There is an interest in alternative energy sources since the major part of all energy consumed which comes from petroleum, charcoal and natural gas. When making the plastic, the scientists heat-treated the feathers to clean them and then pulverized them into a fine powder. They then added chemicals that made the keratin molecules join together into long chains and create a polymer. The resulting plastic was stronger than other bioplastic made of soy beans or starch and it stood up to water.

The material is a thermoplastic which means that heat can be used to mold it into various products and can be melted and remolded many times. It could be used for plastic plates and cups or even furniture and when those things are no longer usable, the plastic is biodegradable. Chicken feather meal consists of processed chicken Feathers. The meal has a 12% fat content, which could be used as a nonfood feedstock to make biodiesel. Recently, researchers using Keratin from chicken feathers is a by-product which is available in great amounts for making bioplastic.

The amount of this waste is continuously increasing with the increase in fowl meat production. Keratin has hydrophilic properties which would be appropriate to use for manufacturing fibers with increased sorption features⁴⁻⁶.



MATERIALS AND METHODS

Chicken Feather Powder

Chicken feathers waste was obtained from a poultry processing unit, Tenali, Andhra Pradesh, India. Feather waste was brought to the laboratory and washed several times with water mixed with neutral soap solution and sodium chlorite to remove blood, manure and extraneous materials. The clean feathers were then spread on iron sheets and dried under the sun for three days. Dried feathers were chopped in to long pieces then ground into powder form Wiley Mill. Add 5g of the blended chicken feather powder to the 100 mL of 0.5M sodium sulfide and 2M sodium hydroxide solution and stir for 2 hours at 30°C. The solution is then filtered and centrifuged at 10,000 rpm for 5 minutes. The supernatant liquid carefully collected using filter paper and 2N Hydrochloric acid was added to the solution to make the pH 4.2. Pour the precipitate mixture onto a Petri dish and then leave it to dry out at 50°C for an hour to make the bioplastic⁴.

Crude EPS extraction from a marine bacterium

The biofilm producing marine bacterium⁷ was collected from Vignan's University, Guntur (Andhra Pradesh). The overnight culture was and centrifuged at 10,000 rpm for 20 min at 4°C to remove bacterial cells. The obtained supernatant was collected into a fresh vial and precipitated with two volumes of absolute chilled ethanol by incubating the mixture at 4°C for overnight. The precipitated EPS was collected by centrifugation at 10,000 rpm for 20 min at 4°C and the supernatant was decanted. The pellet containing EPS was dried at room temperature. To the 1ml of crude EPS add 1ml of 5% phenol and then add 5ml of concentrated H₂SO₄ and measure the absorbance after 10 minutes at 480 nm against blank. Then compare it with standard solution of glucose⁸.

Media and culture conditions for hydrolysis of keratin

The basal medium is used for growth of *Bacillus Subtilis* for analysis of the feather-degrading activity contained the following (in grams per liter): NH₄Cl, 0.5; NaCl, 0.5; K₂HPO₄, 0.3; KH₂PO₄, 0.4; MgCl- 6H₂O, 0.1; yeast extract, 0.1; pH was adjusted to 7.5. 5% of the feather powder was added to the basal medium in various amounts. Feathers were washed in distilled water prior to being sterilized by autoclaving (120°C at 15 lb/in² for 20 min) and incubated in an orbital shaker at 100 rpm at 37^o C for 7 days⁹.

Estimation of keratinase activity

For 2ml of *azokeratin* (1%w/v), 0.5ml of supernatant was added, incubated for 30min at 45°C. The enzymatic reaction was stopped by adding 2.5ml of 10% TCA (Trichloro Acetic Acid) and the allowed to settle for 30min and then filtered. To 1ml of the filtrate add 5ml of 0.5ml sodium bicarbonate solution and 0.5ml of diluted folin phenol cioculate reagent and incubated for 30min. The absorbance was at determined at 440 and 595nm. The average of both wavelengths was taken as the final OD¹⁰.

Tensile Strength using spring testing machine

The ability to resist breaking under tensile stress is one of the most important and widely measured properties of materials used in structural applications. The force per unit area (MPa or psi) required to break a material in such a manner is the ultimate tensile strength. Carefully peel the plastic film from Petri dish Cut 1cm x 3cm rectangular testing template Use the C-clamps fix the sample at both ends of the rectangle. Attach the hook of the spring scale to one clamp. Hold one C-clamp stationary by pulling the other clamp slowly until the sample breaks. Measure the cross-sectional area⁷.

RESULTS AND DISCUSSION

Tensile strength

Taking into consideration of our obtained results we can conclude that type and amount of applied plasticizer as crude EPS affected the mechanical properties of the bioplastic^{7,11}. Changing the type and concentration of the plasticizer and amount of can definitely modify the strength and extensibility of the bioplastic as shown in the table 1.

Sample	Additives	Cross-sectional Area (Thickness x width)	Tensile Strength (MPa)
Feather waste	Crude EPS	1cm x 3cm	23
Feather waste	NO	1cm x 3cm	21
Polyethylene	NO	1cm x 3cm	15
Polysterene	NO	1cm x 3cm	40

EPS estimation and Keratinolytic activity

The crude EPS was isolated from the marine bacterium as shown in (figure 1) using ethanol precipitation method¹² and the EPS concentration was found to be 19.2µg/mL. The keratinolytic activity of 7 days of incubation was estimated by using keratin enzyme and azo-keratin. The keratinolytic activity of *Bacillus Subtilis* was 1.23 IU/mL and the bacillus turns the media more alkaline exhibiting higher keratinolytic activity and utilization of feather keratin.

CONCLUSION

From the obtained results we conclude that the flexibility and other mechanical properties of the bioplastic was improved by the addition of the EPS which acts as a plasticizer that traps the water in the crude precipitate containing keratin units by making the product less crystalline and reduces surface tension thereby increasing the flexibility and a high tensile strength of it. Bioplastic that was prepared using plant crops has several disadvantages since they need food crops which lead to the crisis and hike in the prices, our obtained results conclude that the bioplastic made from feather waste is harder and exhibiting good flexibility resulting in an increase in tensile strength.



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