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Bioplastic Synthesis from Fish Scale Based Chitosan - A Review

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ARTICLE DETAILS

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ABSTRACT

Plastics are used extensively in building, packaging, and other fields on a regular basis. This is a result of plastics' adaptability, strength, and low weight. Because they are a non-biodegradable waste, plastics cause severe pollution that is impossible to control globally. Fish markets that are heavily contaminated by fish waste, such as shells, cause significant pollution on the planet. The extraction of chitosan from the fish shell has reduced environmental contamination from the production of bioplastic from fish scales. Recent research indicates that the packaging business is more affected by the use of bioplastics. The fish's scales were scraped clean of any loose tissue, cleaned, and sun-dried for a week before being exposed to chitosan.The three processes of deproteinization, demineralization, deacetylation, and synthesis of a chitosan-based bioplastic film are used to extract the chitosan from fish scale. The purpose of the degradability test was to determine whether the bioplastics that were produced would break down when exposed to soil microbes. FTIR spectroscopy is used to analyze the film in order to determine how the ingredients in the biofilm interact. The film's production costs are low and reasonably simple. After fish are cleaned, a lot of fish scales are thrown out incorrectly at the market or at home; as a result, fish waste is recycled and used.

1. Introduction

The number of fish processing facilities in Indonesia indicates the significant potential of the country's fisheries processing sector. Fish processing byproducts have the potential to harm the environment.The fish processing business barely consumes 40–50% of the flesh, according to Ifa et al. (2018). The remainder—scales, skin, bones, gills, and internal organs—becomes garbage. The development of disagreeable smells that can disrupt activities and the health of the neighborhood, detract from the area's aesthetic appeal, and lower the water quality in the waste disposal area are examples of environmental harm. Fish scales are one type of fish waste that may be processed and used to create additional materials for the production of bioplastics, which is one strategy to minimize pollution and provide fisheries waste economic value. PLA (Polylactic Acids), cellulose from plants, and starch may all be used to create bioplastics, or biodegradable plastics, which are safe for the environment (Ramadhani and Firdhausi 2021).

Moreover, chitosan may be used to create bioplastics. Because of its non-toxic and biodegradable hydrophobic qualities, chitosan is utilized as an extra ingredient in the production of bioplastics to enhance their qualities (Ramadhani and Firdausi 2021). Chitosan, a biopolymer with the chemical formula $C6H9NO3$, is generated from chitin.Because fish scales contain chitin, they may be used as a raw material to make chitosan from fish waste. Three procedures are typically used to separate chitosan from chitin: deproteination, demineralization, and deacetylation (Fadli et al., 2018).

The thickness and water absorption (swelling) have an impact on whether or not the bioplastics from GSJ: Volume 9, Issue 10, October 2021 ISSN 2320-9186 2391 GSJ© 2021 www.globalscientificjournal.com are used. This article looks at the process of making bioplastics from chitosan that is extracted from fish scale waste.

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2. Fish scales

The integumentary system, which includes fish scales, serves as the body's outermost line of defense. According to Fitriana (2021), there are five different types of fish scales: placoid, ganoid, cycloid, cosmoid, and ctenoid. The stingray and shark have placoid scales, which are tapered and resemble fine, enamel-coated spines; alligator fish have ganoid scales, which are rhombus-shaped; carp have cycloid scales, which are slightly oval in shape with growth lines; and tilapia have ctenoids, which are slightly oval in shape with teeth on one side.

2.1 Fish scale content

The nutritional components of fish scales include 70% water, 27% protein, 2% ash, and 1% fat (Fadilla et al., 2019). According to Wibowo (2016), the proximate content of fish scales is 33.4% water, 0.55% protein, 22.5% ash, and 35.35% fat. Additionally, fish scales are said to contain calcium, alkaloids, steroids, chitin, saponins, and phenols.Additionally, according to Talumepa et al. (2016), dried marine fish scales typically contained 11% water, 30% protein, 39% ash, 5% fat, and 15% carbs. Fish size, habitat, and species all affect the chemical composition of their scales (Ramadhani and Firdhausi 2021).

2.2 Use of fish scales

One type of trash produced by the fish fillet industry is fish scales. Without any processing, fish scale waste will continue to build up and produce an unpleasant stench that might ruin an area's aesthetic appeal. Numerous researchers have documented a variety of applications for fish scales. Dewantoro et al. (2019) claim that fish scales can be used as gelatin to thicken syrupAccording to Setyowati (2015), chitosan from fish scales can be used as an additional material in the production of bioplastics, and it can be used as a preservative in the food, health, and agricultural sectors as well as to lower metal levels in water (Ramdhani and Firdhausi et al. 2021).

2.3 Chitosan

Chitosan shares the same chemical structure as chitin and is derived from chitin and has a yellowish white tint. Two steps are involved in the production of chitosan: first, chitin is isolated through deproteination, demineralization, and depigmentation; next, it undergoes a process called chitin deacetylation, which turns it into chitosan by reacting it with a high concentration of alkali for an extended period of time at a high temperature (Setha et al. 2019).From the original form of pure chitin, chitosan can be obtained in a variety of morphological forms, such as irregular structures, crystalline or semicrystalline forms, or a white amorphous solid with a fixed crystal structure. Chitosan has shorter chains than chitin, is soluble in acidic solutions, and has high biological and mechanical properties, such as being biorenewable, biodegradable, and biofunctional (Pratiwi et al. 2014).

Figure 1: Bioplastic made from chitosan from fish scale (Pratiwi et al. 2014).

2.4 Bioplastic

Plastic is used for home purposes, such as wrapping food and beverages and other requirements, because it is inexpensive and lightweight. However, because it is difficult to decompose, its use has an adverse effect on environmental sustainability. A number of research have been conducted to either decrease the usage of plastic or substitute it with eco-friendly packaging, such as biodegradable or bioplastic.The primary elements frequently utilized in the production of biodegradable plastics are starch and Poly Lactic Acid (PLA). Bioplastics are plastics that may break down quickly and are composed of natural polymer materials like starch, cellulose, and fat (Kamsiati et al. 2017). Additionally, fish scales can be used to make bioplastics, which is one way to process fish waste (Aziz et al. 2017).

3. Manufacturing Process

The method by which Aziz et al. (2017) Produce chitosan from fish scales for bioplastics 1. Preparation of the Sample To make the process of flouring easier, the waste waste from fish scales is washed and dried until the scales become brittle. An oven is used to dry the fish scales and create a fine powder. b) Chitin isolation.The process of separating chitin from fish scale powder involved two steps: demineralization and deproteination. For two hours, deproteinized fish scale powder is combined and agitated in a 3.5% NaOH solution with a fish scale to NaOH 1:10 (m/v) ratio at 100°C.After filtering and washing the results with distilled water until the pH was neutral, the precipitate was dried in an oven set to 50°C for three hours. After that, the deproteination product was demineralized by reacting it with 1 N HCl solution at a ratio of 1:6 (m/v) for half an hour at room temperature. After filtering and washing the results with distilled water until the pH was neutral, the precipitate was dried in an oven set to 50°C for three hours. b) Preparing Chitosan,the acetyl group in the chitin extract from fish scales was broken in order to prepare chitosan.Chitin was dissolved in 50% NaOH at a ratio of 1:10 (m/v) for one hour at 100° C to perform the deacetylation process. After filtering and washing the results with distilled water until the pH was neutral, the precipitate was dried in an oven set to 50°C for three hours. d) Bioplastics production Two grams of chitosan were dissolved in 25 milliliters of 1% acetic acid at 60 degrees Celsius for an hour, stirring continuously, to create bioplastics.After adding 1 mL of sorbitol, the mixture was mixed once more for 15 minutes at 60° C, or until it was quite thick. A cement mold, aluminum foil, and a glass container are then printed with the solution, and the cement mold is baked at 60 degrees Celsius until the plastic hardens.

4. Physical Properties of Bioplastic

The thickness and water absorption (swelling) tests reveal the physical characteristics of bioplastics made from fish scale chitosan. To ascertain the bioplastics' capacity and resistance to water, the swelling test was conducted (Maladi et al., 2019). To find out the proportion of plastic development after soaking in water, the test procedure involves submerging the plastic in water. The results of this test can be used to assess the physical characteristics of the plastic, including its waterproofness. Despite having a high absorption capacity, bioplastics have a harder time dissolving in water when the swelling test value is higher. Conversely, when the swelling value is low, the presence of H2O that diffuses into the water makes the bioplastics more easily destroyed (Augustin et al., 2016). As to Coniwanti et al. (2014), bioplastics with greater water resistance values would have better water-holding capacities; conversely, bioplastics with lower water resistance values will have poorer qualities. b) Bioplastic is thick. A micrometer screw is used to measure the thickness of bioplastics. One of the factors that affects the thickness of bioplastics is the addition of chitosan; a high concentration of chitosan will affect the thickness of the bioplastic. Thickness is a characteristic that determines the speed of transfer of water vapor, gas, and other volatile compounds (Ramadhani et al. 2021).

5. Sources of chitosan

- The most common industrial source of chitosan is the shells of crustaceans, such as crabs, prawns, and shrimp. These shells are readily available as waste from the seafood processing industry.
- Fungi: Chitosan can be obtained from the cell walls of some fungi. This method is an alternative to using crustaceans, as it doesn't rely on environmentally harmful chemicals.
- Insects: Chitosancan be obtained from the exoskeletons of insects, such as beetles.
- Silk Industry: Chitosan can be obtained as a side-stream product from the breeding of cocoons in the silk industry.
- Proteins extraction: Chitosan can be obtained as a by-product of proteins extraction from insects for food or animal feed.

5.1 Advantages of using chitosan

- Antimicrobial activity
- Chitosan has a broad spectrum of antimicrobial activity against many foodborne microorganisms. It's more effective against Gram-negative bacteria, and is less toxic to mammalian cells than other disinfectants.
- Antiviral activity: chitosan can inhibit viral infection and induce an antiviral immune response
- Biodegradable and biocompatible: chitosan is non-toxic and biodegradable, making it a good choice for medical application.
- Wound healing: chitosan -based hydrogels are ideal for wound healing because they are biodegradable, biocompatible, and have antimicrobial, hemostatic, and other biological effects.
- Tissue engineering: chitosan porouy structure allows for gas permeation, water, absorption,cell interaction, and the incorporation of drugs, growth factors, and stem cell.
- Delivery carrier: chitosan has great potential as a delivery carrier for drug and other therapeutics.

5.2 Disadvantages of using chitosan

- Mechanical resistance: Chitosan has low mechanical resistance, which can be a drawback in some applications.
- Pore size: It can be difficult to control the pore size of chitosan.
- Thermal stability: chitosan has low thermal stability.
- Water resistance: chitosan films have poor water resistance.
- Sensitivity to humidity: chitosan is highly sensitive to humidity.

6. Global usage of fish waste

- Animal feed: Fish waste can be used as feed for fish, swine, and poultry.
- Food products: Fish waste can be used to make fish cutlets, fish fingers, and fish sauce. Fish protein hydrolysate can be used as a milk substitute and food flavoring.
- Cosmetics: Collagen from fish skin can be used in cosmetics.
- Pharmaceuticals: Fish waste can be used to make pharmaceutical products such as collagen, fish bone extracts, and polyunsaturated fatty acids.
- Energy: Fish waste can be used to produce biodiesel and biogas.
- Fertilizers: Fish waste can be used to make organic fertilizers.
- Water treatment: Fish scales can be used as natural adsorbents to coagulate organic wastewater.
- Food packaging: Chitosan from fish waste can be used in food packaging.
- Soil fertilizer: Fish waste can be used as a soil fertilizer.
- Enzyme isolation: Fish waste can be used to isolate industrial enzymes such as proteases, alkaline phosphatase, and hyaluronidase.
- Natural pigments: Fish waste can be used to extract natural pigments.

➢ Leather: Fish waste can be used to make leather.

7. Conclusion

The above literature study's findings suggest that chitosan derived from fish scales is used to make bioplastics through the steps of combining (chitosan, acetic acid, and sorbitol), shaping, and drying. The synthesis of bioplastic involve several steps, including extraction, purification and modification of chitosan, followed by blending with other biopolymer or additives to enhance its properties various methods such as solvent casting, and infection molding, can be used to process the bioplastics. Over all, the synthesis of bioplastic from fish scale-based chitosan offers a sustainable and innovative solution for reducing plastic waste and promoting a circular economy. With continued research and development, this bioplastic has the potential to play a significant role in shaping a more environmentally friendly future.

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