

ADVANCES IN AQUACULTURE AND FISHERIES RESEARCH

Editors
Prof. Dr. Aysun KOP
Assist. Prof. Dr. Boran KARATAŞ

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CHAPTER 5

BIOPLASTIC RAW MATERIALS OBTAINED FROM AQUATIC ENVIRONMENTS

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1. INTRODUCTION

It's like the whole world is wrapped in plastic. Plastics are among the indispensables of our daily lives and are used in household appliances, cars, sports equipment, office and information technologies and packaging. The decomposition time of petroleum-derived plastics in nature is very long. For this reason, they create a waste problem and are difficult to separate in recycling. There are several solutions to the environmental pollution problem caused by non-degradable plastic waste. These are incineration, recycling or producing and using biodegradable plastics.

With the combustion removal method, harmful gases (such as hydrochloric acid and hydrogen cyanide) are released into the air we breathe. This situation brings with it factors that threaten human health. Emission of these gases also poses a major threat to the global warming problem by causing the greenhouse effect. It takes a long time to sort plastic waste materials in recycling applications. It is also an expensive application. For all these reasons, bioplastic production, which is an alternative application, appears as a solution proposal.

Native polymers like proteins, polysaccharides and lipids or a mixture of the ingredients play a role in the readying of biocomposites. (Figure 1). Biocomposites formed from plastics of biological origin called 'biopolymer' or 'bioplastic' are called 'green composites'.

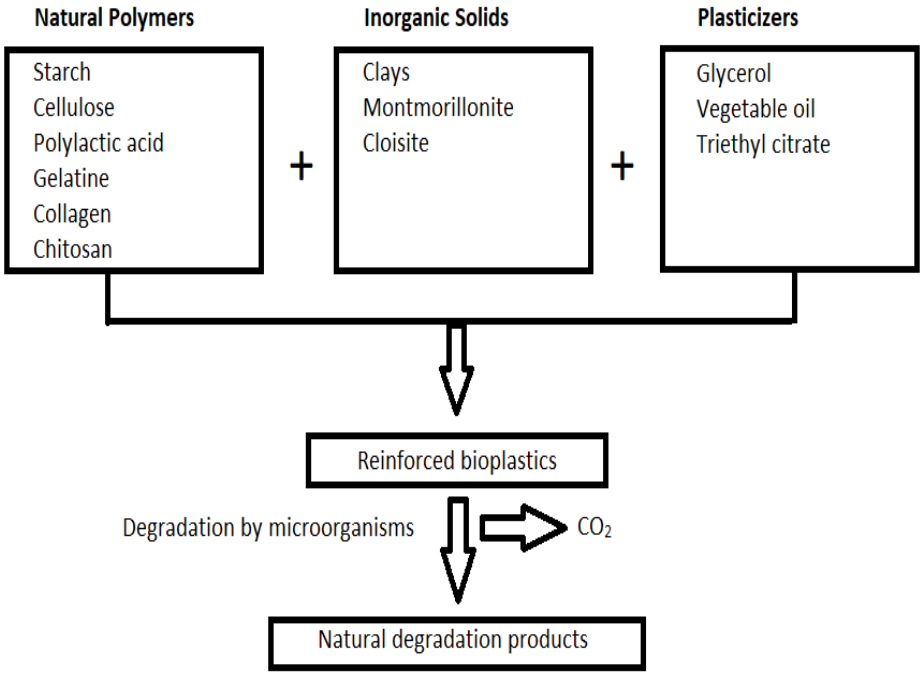


Figure 1. Additives that can be used during the formation of bionanocomposites (Dursun et al., 2010).

Bioplastics can be classified into three categories (Figure 2). Except the fossil based non-biodegradable plastic, rest three are considered under the category of bioplastics. True bioplastics (bio-based and biodegradable) are a very valuable material in the plastics industry. Because;

- It is completely degradable in nature.
- Eliminates the need for petroleum.
- It is created utilizing renewable energy sources.
- It has the physicochemical characteristics of synthetic plastics.

Of all the biodegradable plastics, only poly(3-hydroxyalkanoate) is completely degraded by microorganisms when it accumulates inside the cell during uneven growth conditions.

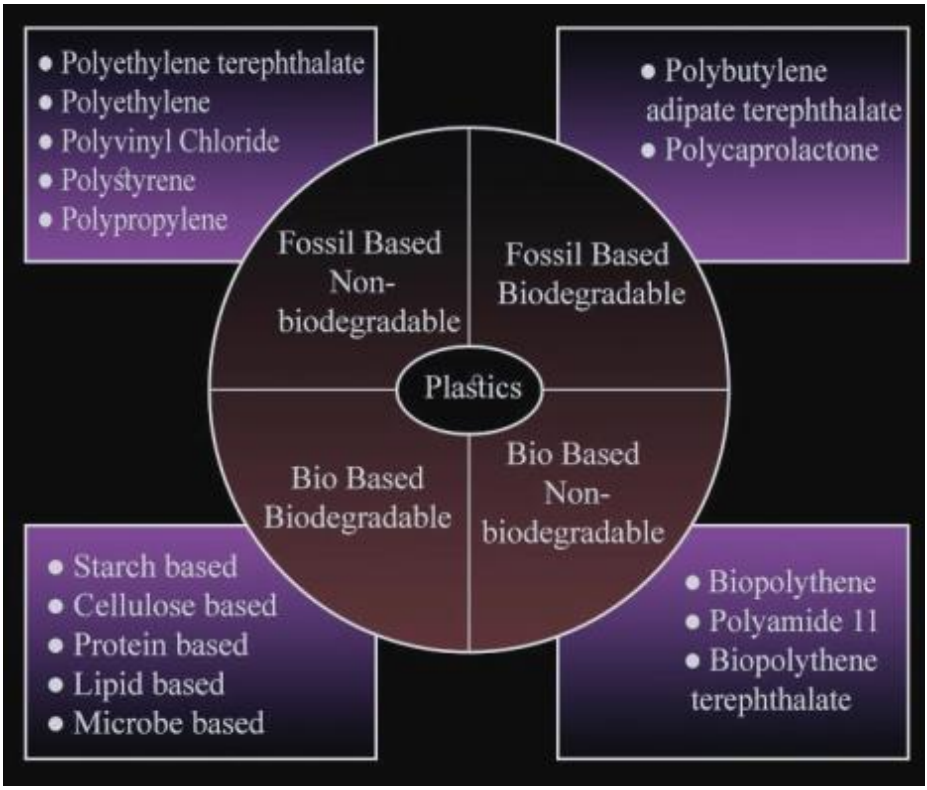


Figure 2. Types of Plastics, Their Degradability and Examples (George et al., 2021).

2. AQUATIC RAW MATERIALS

2.1. Raw Materials From Aquatic Microorganisms

Bioplastics can be made from polysaccharides produced by algae. Phytoplankters secrete mucus-like organic substances under certain conditions or when they die, causing mucilage formation. In 2021, mucilage was seen in the Sea of Marmara and caused serious problems in many respects. Mucilage has the potential to be converted into a plastic material, thanks to its polysaccharide structure. Bioplastics to be produced from mucilage have been presented as a disposal method for the removal of mucilage. When polyvinyl alcohol, a biodegradable polymer, was compared with mucilage, it was observed that mucilage was better in terms of mechanical properties, UV protection and antibacterial activities.

Biodegradable plastic films were prepared from Spirulina, a cyanobacterium. Spirulina has been used in Spirulina/PVA mixtures in the

presence or absence of microbial transglutaminase crosslinker at various concentrations. In addition, Spirulina was used as a single component at various plasticizer and enzyme concentrations. In addition, films modified or unmodified with microbial Tranglutaminase were prepared by extracting the proteins of Spirulina.

2.2. Raw Materials From Shellfishes

Millions of tons of crustaceans such as shrimp, mussels, oysters, lobster and crab are produced worldwide each year. The edible parts of them are very rich in protein. However, other inedible parts (waste) constitute approximately half of the body weight. Shells are an important source of polysaccharides (chitin) and protein. Chitin is a linear homo-polysaccharide composed of b-(1,4)-linked N-acetyl-D-glucosamine units. Chitosan is not extensively found in environment and is a deacetylated configuration of chitin get from crustaceans fall-out. Chitosan possesses characteristic properties such as solvability in weak acids, film making capability, pH sensitiveness, biological degradability and biological compatibility, non-antigenicity, non-toxicity and being economical. It is therefore gaining attention to uses at the aliment, biomedical and dye industries. In the context of the food industries, chitosan-based composite films and coatings are produced to extend the post-harvest life of fruits and vegetables.

Chitosan is used in the preparation of biodegradable films, blends, coatings, composites and nanocomposites. For this reason, it attracts the scientific world and different sectors.

Crustacean shells generally consist of 20-30% chitin, 30-40% protein, 30-50% calcium carbonate/phosphate. Apart from this, it also comprises several pigments (astaxanthin, cantaxanthin, lutein or β-carotene).

2.3. Raw Materials From Fishes

Industrial fish processing wastes can constitute up to 70% of the initial weight of the fish. This waste is noted a high-quality and inexpensive raw material. It often cause environmental, health and economic damage. Fish waste is converted to bioplastic for use. The wastes included in the production contribute to the reduction of environmental pollution.

There are opportune characteristics, such as plasticity and elasticity, and mechanical and airtight barriers, in bioplastic production from fish proteins (Figure 4).

Chitosan has been obtained from fish scales and other wastes of fish, the squid gladius (*Loligo vulgaris*). Myofibrillar proteins, collagen and gelatin were obtained from the fish by-product. Biopolymers extracted from fish by-products have been effective in obtaining bioplastics. Thus, the environmental impact of waste disposal can be reduced.

In addition to chitin, the existence of collagen in the construct of fish scales was also confirmed. Among natural amino polysaccharides, chitin is the most plenty, following cellulose. Chitin extracted from the scales of carp (*Cyprinus carpio* L.) has been characterized by its functional properties.

The stages of bioplastic production from fish scale are as follows. First, the fish will be collected and scaled. Then the melted fish flakes are leavened in a glass utensil at a room temperature of 26-38°C for three months. As leavening happens, bacteria augmented on the flakes. After the leavening procedure, the leavened flakes are subjected to cell disruption, washing, centrifugation and drying to purify the biopolymer. Then, the purification of the biopolymer takes place with the steps of cell dispersion, washing and centrifugation, drying. The final step is bioplastic production (Figure 3).

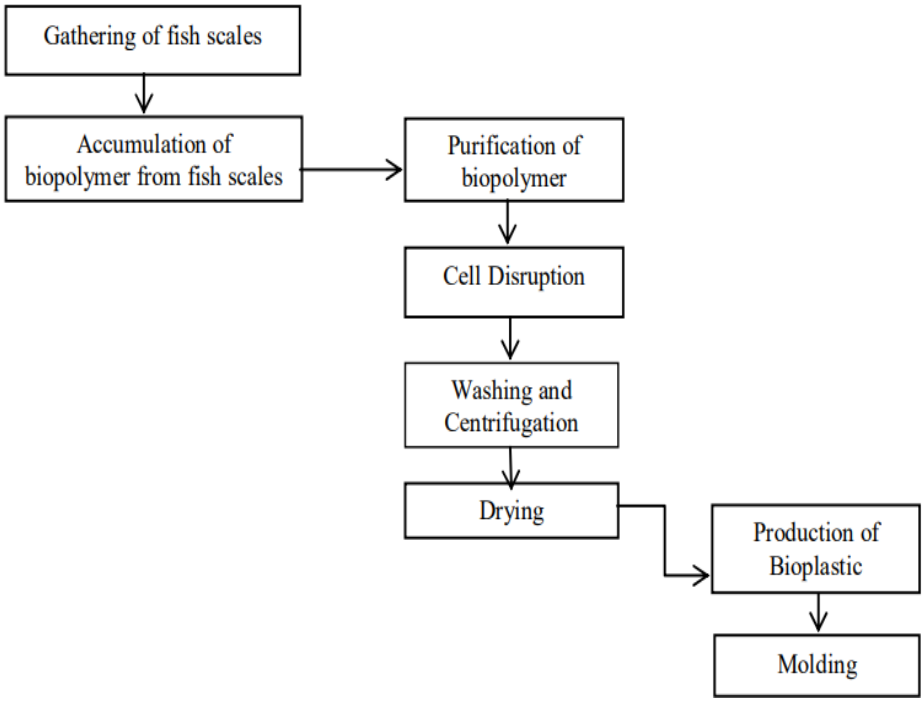


Figure 3. Schema of process of bioplastic (Varna et al., 2019).

Bioplastics containing 0.79% myofibrillar proteins (*Brachyplatystoma rousseauxii* wastes) and 40% plasticizer were found to be homogeneous, transparent, strong, flexible. Permeability of water vapour and solvability of the bioplastics were low.

Bioplastics were obtained by adding different amounts of chitosan (2%, 3%, 4%) and fish bone gelatin (5%, 10%, 15%, 20%). The most efficient mixture in terms of thickness (0.072 mm), transparency (2.09), tensile strength (19.05 MPa), percent elongation (28.333%) and biodegradability is the package produced with the addition of 2% chitosan and 5% gelatin concentration. Bioplastics made from this mixture degraded 99.84% after 14 days.

In a study investigating the effect of microcrystalline cellulose on bioplastic, fish scale powder, wheat gluten, silica, and glycerol were used in the mixture. Microcrystalline cellulose improved the chemical stability and tensile strength of the bioplastic. As a result of the biodegradability tests, the weight of the bioplastic decreased by 35% in 14 days.



Figure 4. Optimized bioplastic prepared using myofibrillar proteins from gilded catfish (Araújo et al., 2018).

Biodegradable films have been developed from a blend of fish gelatin and myofibrillar. For this, the fish proteins were removed from the fillet leftover of *Macrodon ancylodon*. According to mechanical analysis, myofibrillar protein films are more resistant to traction, while gelatin is more flexible. Water vapor permeability and solubility were found to be low in the blend biofilms. These films are transparent, mechanically strong and flexible. This confirmed that the properties were improved by mixing the polymers. The analyzes revealed the coaction of gelatin and myofibrillar protein chains with each other. In this way, it was revealed that the films formed a cohesive and strengthened matrix resulting in great thermal resistance. It has been determined that bioplastic food packaging can be produced from the mixture of polymers.

3. CONCLISION

Many studies have been conducted on the production of bioplastics with raw materials obtained from aquatic environments. Collagen, gelatin, chitin and chitosan in aquatic microorganisms, fish and crustaceans play an important role in the production of bioplastics.

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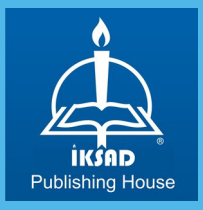
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