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Overview Of Fish Wastes As A Packaging Material

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Abstract
Plastic packaging plays an important role in food safety, however difficulties such as non-biodegradability, recycling difficulty, and the leakage of dangerous chemicals into food and soil raise severe concerns about human health and the environment. As a result, there is an urgent need for bio-sourced polymer alternatives to non-biodegradable food packaging materials. Bio-based packaging materials are a growing alternative to traditional polymers. Natural biopolymers compete economically with conventional ones due to their widespread availability, ease of processing, biodegradability, compostability, and strong mechanical and barrier qualities. Bio-based polyesters provide a wide range of materials, from stiff to soft, with characteristics that range from partially to totally biodegradable. Fish waste is becoming increasingly popular as a new raw material for biopolymer manufacturing in a variety of applications, mostly in food packaging, due to significant economic and environmental benefits. The challenges of fisheries industry waste and by catch, as well as the possibilities for reusing these byproducts in a circular economy strategy, have been thoroughly discussed. Then, all of the biopolymer formed from fish waste with possible applications in food packaging were detailed, including muscle proteins, collagen, gelatin, and chitin/chitosan. It is believed that almost two-thirds of all fish is wasted, causing significant economic and environmental consequences. In this study, we highlight the significant impact that fish waste might play in the socioeconomic sector. This paper discusses the various substances of significant commercial value derived from fish byproducts, such as collagen, enzymes, and bioactive peptides, and their potential applications in packaging materials.
Keywords: *fish waste, packaging, enzymes, collagen, bioactive peptides.*

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I. Introduction

Plastics are regarded to be the most widely utilized materials, particularly in packaging applications. Currently, global plastic production is at 320 million tons per year, with increasing demand reflecting its broad-spectrum application in a variety of fields (paletta, leal filho, balogun, foschi, and bonoli, 2019). Polymers widely utilized for this purpose include pvc, pet, pp, pe, pa, ps, and evoh (luzi et al., 2019; martínez-abad et al., 2012). They are recommended due to their superior barrier and mechanical qualities, widespread availability, and low cost (park, koo, cho, & lyu, 2017). However, the disposal of synthetic plastics causes greenhouse gas emissions, including carbon dioxide and methane accumulation in the environment, which has serious environmental effects (jain & tiwari, 2015). As a result, the usage of fossil-based plastics is limited due to their inability to be recycled or biodegradable. Therefore, it is highly vital to progress towards alternate raw materials for plastic production (ahmed et al., 2018). Fish waste is thus a developing issue that requires novel approaches and solutions. To achieve this goal, numerous projects and methods have been implemented worldwide to reduce food waste . In 2015, the united nations established the sustainable development goals to ensure sustainable consumption and production in order to significantly reduce global per capita food waste while also protecting marine and maritime environments . The need to apply more sustainable methods in the fishing and aquaculture sectors necessitates the valorisation of byproducts and discards . Recently, it was demonstrated that a circular economy concept may be successfully implemented to the seafood business by reusing by-products . This approach might be in principle applied to fishery by-catch, contributing to developing eco-friendly solutions.

II. Biodegradable Replacement To Conventional Plastics

Biodegradable polymers (bdps) or biodegradable plastics are polymeric materials that are "capable of undergoing decomposition into carbon dioxide, methane, water, inorganic compounds, or biomass in which the key process is the enzymatic action of microorganisms. Under appropriate conditions, initial steps may include abiotic (thermal, light) and biotic mechanisms to breakdown the polymer to a low-molecular weight species. However, the resulting breakdown pieces must be fully utilized by microorganisms; otherwise, there is a risk of environmental and health effects (narayan 2006). The output of an industrial composting process (usually 12 weeks with an elevated temperature phase above 50°c) must meet quality criteria such as heavy metal (regulated) content, ecotoxicity, and the absence of visible polymer residue. Bdps can be classed as bio- or petrochemical-based, depending on their origin. Polysaccharides (e.g. Starch, cellulose, lignin, and chitin), proteins (e.g. Gelatine, casein, wheat gluten, silk and wool), and lipids (e.g. Plant oils and animal fats) are mainly biodegradable and derived from natural sources (plants, animals, or microorganisms). This category includes natural rubber and certain polyesters produced by microorganisms or plants (e.g., polyhydroxyalkanoates and poly-3-hydroxybutyrate) or synthesized from bio-derived monomers (e.g., polylactic acid). Petrochemical-based bdps, such as aliphatic polyesters (e.g., polyglycolic acid, polybutylene succinate, and polycaprolactone (pcl)), aromatic copolyesters (e.g., polybutylene succinate terephthalate), and poly(vinyl alcohol), are synthesized from monomers derived from petrochemical refining, which possess certain degrees of inherent biodegradability (clarival & halleux 2005 in smith 2005). The use of a natural feedstock to produce biopolymers can be a desirable innovation if such products demonstrate improved biodegradability while meeting technical specifications, such as physicochemical properties and mechanical functionalities comparable to conventional plastics (e.g., flexibility, brittleness, and rigidity) (elsawy et al., 2017).

III. Biopolymers Derived From Fish Scrap For Food Packaging

Fish waste is becoming increasingly popular as a new raw material for biopolymer manufacturing in a variety of applications, mostly in food packaging, due to significant economic and environmental benefits. Polymers generated from fish waste are, in fact, particularly attractive alternatives for synthetic polymers in the creation of bioplastics ,which can be bio-based, biodegradable, or both .the terms "biopolymer" and "bioplastics" have been used to refer to a wide range of polymers with varying qualities and applications, and they have been given varied meanings .bio-based plastics are made from renewable materials like starch and cellulose, although some of them, such as bio-based polyethylene, are not biodegradable. There is general acceptance on the potential contribution of biodegradable plastics to the decrease of plastic pollution in the marine environment, which has been recognized as one of the most impactful dangers to the environment, creating several harmful and environmentally. Shrimp and fish fillet preparation generates around 50% and 75% of waste, respectively. Approximately 20% of fish industry byproducts are employed as low-value ingredients in animal feed ,while the majority is landfilled or burned, causing environmental, health, and economic damage. Valorizing fish waste could help to reduce the costs of safe waste disposal while also producing additional value from the recovery of numerous potentially useful compounds such as lipids, proteins, pigments, bio-active peptides, amino acids, collagen, chitin, gelatin . Traditionally, collagen was primarily derived from land-based animals such as cattle and pigs. However, in recent years, allergic reactions and outbreaks of bovine spongiform encephalopathy, transmissible spongiform encephalopathy, foot and mouth disease, ovine and caprine scrapie, and other zoonoses have limited their use for collagen extraction . As a result, the widespread use of collagen and its derivatives necessitates the development of new, safer collagen sources. Collagen derived from fish skin, bone, fins, and scales is used to gel, stabilize, foam, and emulsify food products. Similarly, collagen's insolubility, biodegradability, and fibril-forming capacity make it suitable for usage as an active food packaging material.

IV. Protein-Based Biopolymers For Fish Product Packaging

Collagen is the most common animal protein since it is found in all connective tissues (such as skin, bones, ligaments, tendons, and cartilage) as well as the interstitial tissues of parenchymal organs. There are 28 various forms of collagen in nature, but type i is the most abundant and plentiful, and it also makes up the majority of marine collagen. Marine collagen is mostly derived from fish skin, bones, fins, and scales, as well as connective tissue of jellyfish, sea urchins, starfish, and sea cucumbers .fish skin has been used for collagen extraction because it contains around 70-80% collagen. Fish scales are also a promising and low-cost source of marine collagen, constituting around 4% of the entire weight of the annual output of fish offal, which is approximately 18-30 million tons. Fish scales contain both organic (collagen, fat, lecithin, scleroprotein, vitamins, etc.) And inorganic constituents (hydroxyapatite, calcium phosphate, etc. Compared to mammalian collagen, marine collagen has a comparable or slightly lower molecular weight and a lower denaturation (melting) temperature , which is approximately 20-35 °c for most fish species, with higher values for collagen originating from warm-water species. Marine collagen, unlike human collagen, has no religious or transmissible illness limits, as well as great film-forming ability, biocompatibility, low antigenicity, high biodegradability, and cell growth capacity. This waste material has the potential to be used as an environmentally acceptable and low-cost collagen source, with numerous uses in health foods, cosmetics, and biomedicine as drug/delivery carriers or wound dressings . Because of its high water absorption capacity, collagen is an excellent choice for texturizing, thickening, and gel formation. Furthermore, it exhibits remarkable surface behavior qualities such as emulsion, foam formation, stability, adhesion and cohesion, protective colloid activities, and film-forming capability . Although marine collagen is already employed as a food additive to improve food rheological qualities, it is still underutilized, with far fewer applications than mammalian collagen.

V. Polysaccharides-Based Biopolymers For Fish Product Packaging

Polysaccharide biopolymers commonly utilized in fish packaging include cellulose, chitin/chitosan, starch, lignin, pectin, alginate, and κ-carrageenan. In addition to food packaging, bio-based materials have use in microbial filtering, military security, and environmental management. Several polysaccharide-based packaging materials have been developed for fish packing . Polysaccharides can be easily altered to improve their physicochemical qualities by heat gelatinization, ph alterations, cross-linking, and hydrolysis. Gas barrier, mechanical, thermal, and chemical properties of biomaterials are essential considerations when selecting polysaccharides as packaging materials. Chitin is a naturally occurring biopolymer synthesized by a wide range of living organisms .it is the second most abundant natural polysaccharide, following cellulose. Chitin can be derived from a variety of sources, the most common being shellfish waste such as shrimp, crabs, and lobsters. Chitin deacetylation under alkaline circumstances is essential for the conversion of chitin to chitosan. Chitosan's functional properties are regulated by structural parameters such as average molecular weight and deacetylation level . Chitosan is categorized into two types based on its molecular weight: high molecular weight (hmw) (> 300 kda) and low molecular weight (lmw) (300 kda).

VI. Polylactic Acid And Polyhydroxyalkanoates-Based Biopolymers For Fish Product Packaging

Polylactic acid (pla) is made from lactic acid monomers and is commonly used for fish packing during chilling storage. Polylactic acid, polyhydroxyalkanoates, pullulan, and xanthan gum are the most commonly utilized microbial polymers in fish packaging. Phas are ideal for food packaging materials due to their air stability, nontoxicity, hydrophobicity, and purity of enantiomer.

VII. Integration Of Nanofillers Into Biopolymers

Nanofillers are nano-sized compounds that keep food microbiologically safe while also improving the mechanical, thermal, oxygen, and moisture barrier qualities of bio-based meat, fruit, and seafood packaging. Montmorillonite, nanofibers, nanowhiskers, silver, copper, zinc oxide, and titanium dioxide are often used nanofillers in active packaging.

VIII. Integration Of Bioactive Molecules Into Biopolymers

Bioactive compounds improve polymers' mechanical, barrier, antioxidant, and antibacterial characteristics. Bioactive molecules change color in response to ph, temperature, light, time, and ammonia, serving as a signal of deterioration in packaged fish products. Fish spoilage is typically detected using adenosine triphosphate breakdown, microbial plate counts, total volatile base nitrogen, lipid oxidation, and sensory characteristics. Monitoring fish freshness in real time with chemical, physical, biological, and sensory methods necessitates the use of professional staff and is time-consuming, tiresome, and damaging. The developing techniques employ halochromic (ph-sensitive) bioactive chemicals, allowing consumers and non-specialists to assess the freshness of fish with their naked eyes. Anthocyanins, betalains, and carotenoids are among the ph-sensitive bioactive compounds.

IX. Conclusion And Future Perspective

The conversion of discarded food into useful packaging materials is the main priority for reducing the environmental impact of synthetic plastics. Biopolymers exhibit good physicochemical, thermal, and mechanical qualities whether blended or used alone as packaging materials. Immobilizing nanofillers or bioactive compounds can improve packaging films' morphological, thermal, gas barrier, water vapor permeability, antioxidant, and antibacterial properties. As a result, depending on the type of natural pigment used in fish packaging, these biodegradable packaging materials can be classified as active, intelligent, or smart.

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