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Utilization of Fish Scales for Non-Food Products : A Review

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

This article aims to review the potential of fish scale waste as a processed material and its application to various fields of the non-food industry. The method used in this process is a qualitative descriptive method using data collected from secondary sources. Fish scales are residual waste that can be obtained from waste created in fish sales or fish processing companies. This type of waste has the potential to be utilized because it contains various kinds of organic materials that can be reprocessed to become new products. Fish scales waste can be used directly into handicraft products, including brooches, beading (sequins) and used indirectly in the form of products from collagen extraction, including fish glue and products from chitosan fish scales, including bioplastics, biocoagulants, and Rhodamin B dye adsorbents. The importance of utilizing fish scale waste is that it can increase the selling value of fish scales which were once just waste into potentially useful materials, reduce environmental pollution, encourage the concept of a green economy, and create a *zero waste* environment in the fishery product industry. From the data that has been collected, it can be concluded that fish scale waste can be used in various non-food industries and can be processed into various products, this includes the use of fish scales as

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craft products such as brooches or key chains, processing fish scales into adhesives, and extraction of chitin from fish scales to be used as additives for bioplastics, biocoagulants, and rhodamine b adsorbents.

Keywords: Bioplastics; biocoagulants; crafts; zero waste; absorbent.

1. INTRODUCTION

Fish scales include waste that has not been optimally utilized. Fish scale waste is produced from the fishery processing industry such as the fish fillet industry and the whitefish processing industry. Waste has a negative impact on the environment if it is not treated properly, including fish scale waste. The negative impacts of waste that can be felt by humans and the environment, namely: a) Can cause disease in humans. b) Can spread toxic gases such as sulfide acid (H2S), ammonia (NH3), and methane gas to the environment due to decay with the help of microorganisms. c) Low public health which has an impact on increasing financing for treatment. d) Rising cost of water treatment.

According to [1], fishery waste is estimated to have a proportion of about 30-40% of the total weight of fish, molluscs and crustaceans, consisting of head (12.0%), bones (11.7%), fins (3.4%), scales (4.0%), spines (2.0%), and viscera (4.8%). Waste generated from fishing activities consists of 25% red meat, 55% bone, and 15% entrails. Wasted fish scales can still be utilized because many chemical compounds are contained in fish scales which consist of, 41-84% are organic proteins (collagen and ichtylepidin) and the rest are mineral residues and inorganic salts such as magnesium carbonate and calcium carbonate. Fish scales contain nutritional components, including 70% water, 27% protein, 1% fat, and 2% ash. Protein is the largest component in fish scales [2].

According to [3] Fish scale waste needs to be used for the following reasons, namely: 1). Increase the monetary value of fish scales from what was once just waste to potentially useful materials. 2) Encourage the concept of green economy and blue economy which aims to streamline the utilization of natural resources by producing more derivative products and other related products. 3) Realizing the concept of zero waste in the fishery industry. 4) Reducing environmental pollution. This article aims to review the use of fish scales to be processed into non-food products either directly or indirectly.

2. UTILIZING FISH SCALES FOR CRAFT PRODUCTS

A handicraft product is an item or work of art produced through hand skills that can be used as a priceless symbol and cultural identity. Based on its benefits, there are two craft functions, namely the use function and the decorative function. The function of use, namely handicraft products, prioritizes functional aspects so that they can be used to help a job, while decorative functions, namely handicraft products, prioritizes aspects of beauty or aesthetics so that they can be used as decorations or displays to beautify a room. One of the fish waste products that can be used as material for handicraft products is fish scale waste. Fish scale waste can be used as handicraft products, such as brooches, beading (sequins), key chains, fish scale cactus decorations, rose decorations, and flower basket decorations.

Brooches are accessories made for women's clothing. The way the brooch is made is as follows: Fish scales are cleaned with water and then dried at room temperature (27°C). The next stage is that the dried fish scales are colored by painting with spray paint, then the scales of the snapper are arranged to resemble flowers and given a pin on the back [4].

Fish scales can be made into *beading* raw materials (sequins), which is a type of bowl commonly used to form flower petal formations. The reason why fish can be used as raw material for sequins or beads is because of the sturdy shape of the fish scales is not easily broken and can be positioned as desired, either standing, tilted, face down or on it’s back.

The method of making sequin products made from fish scales can use surface textile techniques, temple techniques, and basting sewing techniques (a type of sewing stitch that has a horizontal direction, where the size and distance of the stitches made on the fabric are always set to the same length) and embroidery techniques. Generally, embroidery techniques is widely used because of the orderly arrangement and beautiful results [4]. Indonesia is one of the countries that uses as acessories. Online stores in the vein of Tokopedia exist a large number of brooches with a price range from Rp22.000,00 to Rp25.000,00 (from US$ 1,4 to US$ 1,6) [5].

3. UTILIZING FISH SCALES FOR ADHESIVE MATERIALS (GLUE)

Fish glue is an adhesive material derived from the extraction and hydrolysis of collagen, one of which is from fish scales. Glue comes from the decomposition of collagen, which is a large number of long-chain proteins. Collagen is insoluble in water, but it can be decomposed by heating in water, as well as other chemicals (acidic or alkaline substances) [6].

According to both [7] and [8] the stages of making glue (adhesive material) from fish scales are as follows: Fish scales are thoroughly washed with water, then soaked in a 0.1 M NaOH solution with a 1:8 weight of fish scales to NaOH solution. Immersion of fish scales was carried out for 6 hours with the replacement of the NaOH solution every 3 hours. After soaking, the fish scales are washed until it reaches a neutral pH level. The next stage is carried out the extraction process, namely fish scales are boiled in a 5% acetic acid solution for 4 hours at 65°C65ºC-70ºC. Extraction results are filtered and cooled to room temperature, then concentrated with a rotary evaporator until concentrated.

Fish scale glue can be used in the paper and wood industry. This type of glue is soluble in water, non-flammable, and non-toxic to humans. Fish glue type products has been present in human society for quite some time. It's use as an adhesive has been recorded as early as the eighth century among european society [9]. But, the usage of collagen derived from fish scales as an adhesive using the methods described above is still in the early stages of development and is currently not being sold commercially at an industrial level. The closest adhesive of this type is traditionally made fish glue used for woodworking such as the StewMac Fish Glue or Talas High-tack Fish Glue. Both have high strength and flexibility suited for furniture restoration or on wood-based musical instruments.

4. CHITOSAN FROM FISH SCALES FOR BIOPLASTICS, BIOCOAGULAN, AND RHODAMIN B DYES ADSORBENTS

In fish scales, there are various compounds that can be extracted by humans. According to [10] fish scales generally contain 20%-30% chitin, 30%-50% minerals, and 30%-40% protein. When compared with chitin extracted from shrimp shells with a content of 40%-60% of their dry weight [11], shrimp shells contain more concentrated chitin. However, the average weight of harvested shrimp is 11-20 grams [12] while fish whose scales can be extracted such as milkfish have an average weight of 7 kilograms at an adult age. The large difference in the size of milkfish will produce more chitin extracted from scale waste per fish than chitin produced from shrimp shells.

When chitin is deacetylated, this biopolymer will turn into chitosan. Chitosan is a biopolymer derived from chitin. Chitosan has hydrophobic, non-toxic and biodegradable properties with a high molecular weight [13]. Chitosan is generally used in wastewater treatment processes and the food industry as food formulations such as gelling, emulsifiers, stabilizers, and binders [14]. However, this biopolymer can also be used as a bioplastic additive, biocoagulant, and rhodamine B dye adsorbent.

Chitosan from fish scales is obtained by means of three processes, namely the process of demineralization, deproteination, and deacetylization. The deproteination process is a process that aims to eliminate the protein content in the raw materials used. This process uses an alkaline solution, often is NaOH. In the deproteination process, the protein will be released and will bind to the Na^+ of NaOH to form a solution of sodium proteinate. The demineralization process aims at eliminating mineral content. In demineralization with alkaline solutions, the process often used HCl. Minerals in the raw material will combine with Cl ions to form mineral salts. Fish scales generally contain the main minerals, namely $CaCO_3$ and $Ca_3(PO_4)_2$. The demineralization process is characterized by the presence of CO_2 gas bubbles during the process. After going through the process of deproteination and demineralization, the final product is formed, namely chitin. The chitin that has been formed is then processed to obtain chitosan through the deacetylization process. The deacetylization process aims to break the acetyl bond ($-COCH_3$) in the acetamide group into an amine group ($-NH_2$). The deacetylization process uses a high concentration of NaOH alkaline solution. The OH group on NaOH will enter the chitin and will make the acetyl group detach so that chitosan is formed [15].

Bioplastics are alternative packaging from plastics that are more easily biodegradable by the environment. Processing of fish scales into bioplastic additives needs to be done to reduce organic waste generated from the fishing industry. In addition, the use of fish scales in this product can reduce costs because this material is a cheaper alternative material [16]. In Indonesia, the manufacture of bioplastics uses starch as a base material because of its abundant supply. According to [17] starch-based bioplastics are less waterproof, weaker *tensile strength*, stiffer, and more perishable than ordinary plastics. In order for bioplastics to remain a valid alternative to plastic, any of these weaknesses needs to be corrected. According to [18] a suitable material to be added to bioplastics from starch to overcome these weaknesses is chitosan.

Chitosan is a biopolymer derived from chitin. Chitosan has hydrophobic properties, is non-toxic and also biodegradable. According to [19], the addition of chitosan in the manufacture of bioplastics will result in more hydrogen bonds so that it will make bioplastics have stronger properties. Furthermore, the addition of chitosan will also make bioplastics have good water resistance properties.

Bioplastics can be prepared by dissolving 2 grams of chitosan into 25 mL of 1% acetic acid while being heated until it reaches 60°C. Such mixing is carried out for 1 hour while stirring throughout. Then, the temperature is maintained at 60°C and then added 1 mL of sorbitol and then stirred for 15 minutes until it is thick enough. The resulting solution is then poured on to aluminum foil, glass containers, and cement molds which are then veneered at 60°C until the plastic solidifies.

The use of bioplastics can be used as packaging for electronic products, packaging in the retail industry, use in the textile industry, replacing plastic pipes, and much more. The use of bioplastics has the potential to reduce the production of existing plastic waste.

Biocoagulants are natural coagulants that play a role in the sedimentation process of small particles that are difficult to settle on their own. Biocoagulants function as binders for dirt or particles contained in water [20]. One of the biocoagulants used is chitosan.

Research conducted by [21], observed the effectiveness of chitosan-based biocoagulants derived from milkfish scales on the waters of Tarakan City which were polluted by tofu industrial waste. In this research, the process of making chitosan is described which consists of three stages: deproteination, demineralization, and deacetylation. The deproteination stage starts with adding 0.1 N NaOH solution to the dried milkfish scale precipitate at a ratio of 1:10 (weight:volume), heated and stirred at a temperature of 65°C for 2 hours constantly, then the resulting solution is filtered. The second stage is demineralization, milkfish scale powder is added with 1 N HCl (1:10 weight:volume) at room temperature for 30 minutes then the solution is filtered. The resulting precipitate is rinsed with distilled water until the pH is neutral and then dried. Thus creating chitin. To obtain chitosan, chitin needed to be deacetylated by dissolving it in 20% NaOH (1:10 weight:volume) for 1 hour at 121°C. The sample was then neutralized until a neutral pH was obtained, then the sample is heated with an oven so that it became chitosan and analyzed its characteristics. After the fish scales have been successfully converted into chitosan, it needs to be further processed to become a coagulant. According to [22], the method begins with dissolving 1 gram of chitosan in 20 mL of 2% acetic acid, then adding up to 100 mL of distilled water, then the solution is stirred. The stirring process uses a magnetic stirrer so that the chitosan can be completely dissolved.

The application of chitosan as a biocoagulant was carried out using the Jartest Flocculator SW1 (Stuart Scientific) method using a stirrer or flocculator [23]. The coagulation-flocculation process is carried out by: tofu waste is added to the chitosan solution then stirred so that a coagulant is formed which is ready to be separated. The application of chitosan is also used to absorb Rhodamine B dye. One of the most widely used dyes in the textile industry is Rhodamine B. Rhodamine B is a compound that is dangerous if it enters the body due to its chemical properties and heavy metal content [24]. Rhodamine B is a compound that has been proven to be carcinogenic to test animals with an oral LD50, mice of 887 mg/kg [25].

One efficient method to deal with industrial waste problems, especially the removal of dyes that is currently widely developed is adsorption. The adsorption method can use a wide variety of adsorbents such as activated carbon, zeolite, bentonite, and chitosan. The use of fish scale chitosan as an adsorbent of Rhodamin B dye can reduce environmental problems caused by waste that occur such as water quality pollution, unpleasant odors, and an increase in bacteria around the disposal area.

5. CONCLUSION

Fish scales are residual waste that can be obtained from waste from fish sales or fish processing companies. This type of waste has the potential to be utilized because it contains a variety of organic proteins that can be reprocessed to become new products. Some processed products that utilize fish scale waste include handicraft products, clothes brooches, *beads* (sequins), products from collagen extraction such as fish glue and products from fish scale chitosan, including bioplastics, biocoagulants, and Rhodamin B adsorbents. The importance of utilizing fish scale waste is that it can increase the monetary value of fish scales which were once just waste into potentially useful materials, reduce environmental pollution, encourage the concept of a green economy, and create a zero waste industry in the fishery product industry. From the data that has been collected, it can be concluded that fish scale waste can be used in various non-food industries and can be processed into various products, this includes the use of fish scales as craft products such as brooches or key chains, processing fish scales into adhesives, and extraction of chitin from fish scales to be used as additives for bioplastics, biocoagulants, and rhodamine b adsorbents.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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