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PROCESSING OF FISHERY WASTE AS AN ALTERNATIVE SOURCE OF GELATIN PRODUCTION

Pengolahan Limbah Hasil Perikanan Sebagai Sumber Alternatif Produksi Gelatin

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ABSTRACT

The Indonesian industry still relies heavily on gelatin imports from countries such as Brazil, India, China, Thailand, and the United States. Unfortunately, the majority of this imported gelatin is made from pigskin, which is haram for Muslims, the majority of Indonesia's population. The use of fish waste for gelatin production is rooted in the need to maximize the utilization of fishery resources and reduce the environmental impact of fishing industry waste. The fishing industry produces abundant waste, mainly in the form of fish bones, skin and scales. Gelatin is widely used for glue manufacturing, cosmetic products, emulsifiers in the food industry, and pharmaceutical products. Gelatin from fish scales can be used as a formulation ingredient in food products such as syrup thickeners, jelly candy, confectionery, ice cream and noodle chewers.

Keywords: Alternative, Fish Waste, Gelatin

ABSTRAK

Industri di Indonesia masih banyak mengandalkan impor gelatin dari negara-negara seperti Brazil, India, Cina, Thailand, dan Amerika Serikat. Mayoritas gelatin impor ini terbuat dari kulit babi, yang haram bagi umat Islam, mayoritas penduduk Indonesia. Penggunaan limbah ikan untuk produksi gelatin berakar pada kebutuhan untuk memaksimalkan pemanfaatan sumber daya perikanan dan mengurangi dampak lingkungan dari limbah industri perikanan. Industri perikanan menghasilkan limbah yang berlimpah, terutama berupa tulang, kulit, dan sisik ikan. Gelatin secara luas digunakan untuk pembuatan lem produk kosmetik, emulsifier pada industri makan, dan produk farmasi. Gelatin dari sisik ikan dapat digunakan sebagai bahan formulasi pada produk pangan seperti pengental sirup, permen jelly, kembang gula, es krim dan pengenyal mie.

Kata Kunci: Alternatif, Limbah Ikan, Gelatin

INTRODUCTION

Indonesia is an archipelagic country with about 60% of its territory consisting of sea and waters. One of the natural resources obtained from these waters is fish. The Indonesian government has tried to increase fish production every year. According to statistical data from (Ministry of Maritime Affairs and Fisheries, 2022) Marine fisheries production reaches more than 7 million tons per year. The part of the fish that is utilized is the meat, while other parts such as bones, scales, and stomach contents that cannot be utilized will become waste. Fish bones, which are about 30% of the total weight of the fish (Sulistyanto *et al.,* 2015.) Utilization of fish waste is very important to note, utilization of waste into a product will reduce environmental pollution. Fish waste is not only thrown away, but can be processed into useful products such as gelatin. This gelatin is the result of collagen hydrolysis and has long been used in various industries, from food, pharmaceuticals, cosmetics, to photography. Gelatin has various functions, such as stabilizing, thickening, emulsifying, forming gels, coating food, packaging sensitive materials, making foam, and forming films. The benefits are not limited to that, gelatin is also used in the manufacture of glue, lipstick, shampoo, soap, and batteries. In fact, gelatin can be combined with pectin and modified starch to produce a chewy candy and jelly texture. Gelatin is truly a versatile product that turns waste into something useful (Normah & Fahmi, 2015).

Industry in Indonesia still relies heavily on gelatin imports from countries such as Brazil, India, China, Thailand, and the United States (Central Bureau of Statistics, 2020). Unfortunately, the majority of this imported gelatin is made from pigskin, which is haram for Muslims, the majority of Indonesia's population. Beef gelatin cannot be consumed by Hindus for religious reasons. Research shows that 45% of gelatin raw materials come from pigskin, 29.4% from cowhide, 23.1% from bones, and 1.5% from other sources (Karim & Bhat, 2009). The high use of pigskin drives the need to find alternative gelatin raw materials that are halal and in accordance with public beliefs. This paper reviews the progress of research on gelatin from fish waste. The aim is to provide researchers with an overview of the potential of fish waste and reference materials for further research, including the search, production, analysis, characterization, and application of gelatin from fish processing waste.

METHODS

This study reviews the scientific literature and recent journals (last 10 years) to explore the potential of gelatin from fish processing waste. Research steps:

a) Journal selection: Journals are selected purposively based on the topic of gelatin from fish processing waste.
b) Journal grouping: Journals are grouped based on the type of waste and the type of fish studied.
c) Comparative analysis: The potential of each type of fish waste.

RESULT

Fish Waste as An Alternative Source of Gelatin

The use of fish waste for gelatin production is rooted in the need to maximize the utilization of fishery resources and reduce the environmental impact of fishery industry waste. The fish processing industry produces large amounts of waste, including skin, bones, and fins, which are often not optimally utilized and can become an environmental problem if not handled properly (Grasela, 2022). Utilizing fish waste as a source of gelatin not only reduces the waste generated but also creates new economic opportunities by producing industrial raw materials from previously unutilized resources. Figure 1 illustrates the method of making gelatin from collagen. Gelatin comes from many sources and has an increasing demand due to its many applications. The production of gelatin from pig skin is the highest in the world, accounting for

46% of total production. The production of bovine bone and bovine skin accounts for 23.1% and 29.4% respectively (Al-Nimry, 2021).

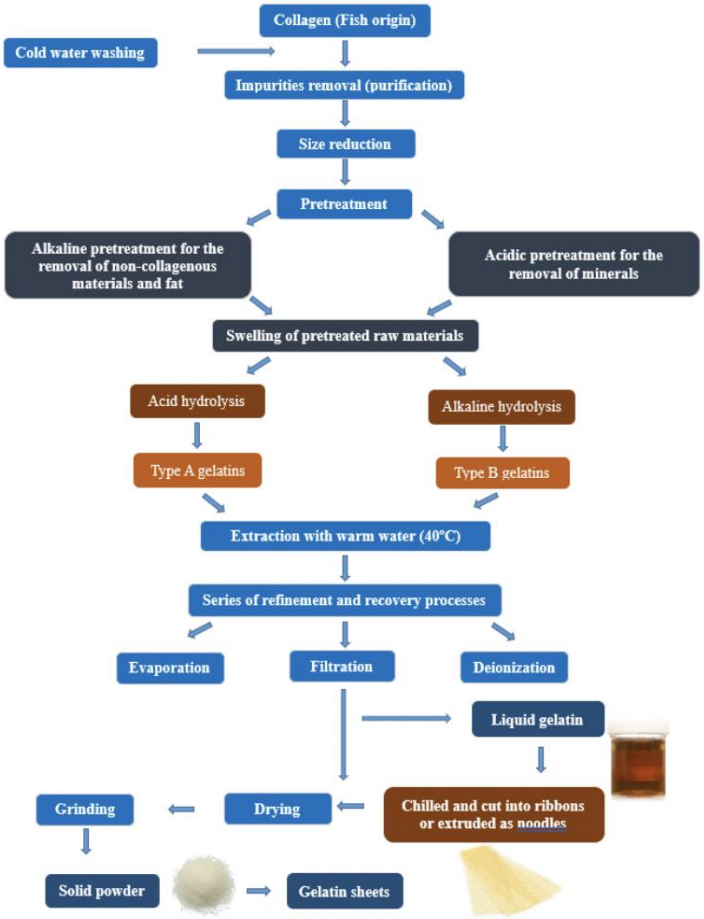

Figure 1. How to Make Gelatin from Fish Collagen (Al-Nimry, 2021)

Characteristics of Fish Waste Gelatin

Gelatin is a natural protein derived from collagen, a structural protein found in animal connective tissue. Collagen is processed into gelatin through a hydrolysis process, which breaks down the protein chains into smaller and more water-soluble ones. Industries such as food stabilizers, pharmaceuticals, and photographic emulsions require high viscosity, while low-viscosity gelatin is needed in the sugar industry (Gunawan & Suptijah, 2017). Gel strength is an important part of gelatin characterization. This is one of the texture characteristics that indicates the ability of a material to undergo certain deformations (Wulandari *et al.*, 2013). Gel strength refers to the mechanical strength of gelatin in maintaining the gel shape and its resistance to separation or deformation. The level of gel strength is measured in bloom units, which is the compressive force required to break or destroy the gel product. The gel strength test measures the force or tension required to destroy or separate gelatin under certain conditions. Gelatin can last a long time and is stable under various processing or storage conditions (Asmawati, 2023). Several studies have described the characteristics of gelatin produced from fish waste, with a pretreatment time of 48 hours and a primary extraction temperature of 75 °C, the best catfish bone gelatin with 1% citric acid. The molecular weight of the gelatin is 162 kDa, and the gelatin yield is 6.14%. Gel strength, chewing power, viscosity, and pH can be easily observed. In addition, the water, ash, protein, and fat content can be measured well and compared with SNI 06-3735 and GMIA.

The physical-chemical characteristics of gelatin were studied on the skin of catfish, tilapia, and tuna. These characteristics include yield, water content, ash content, viscosity, pH, gel strength, and setting point (Nurilmala *et al.,* 2021). The gelatin yield between fish species is very different, mainly due to differences in collagen content, composition, and skin matrix (Koli *et al.,* 2014). Tilapia fish skin has a higher gelatin yield because this fish skin has a high collagen protein content (Table 1).

Table 1. Proximate Analysis of Fish Skin

Parameter (%dw)	Fish Skin		
	Catfish	Tilapia	Tuna
Ash Content	0.42 ±0.01	0.23±0.04	0.3±0.05
Fat Content	8.07±0.1	3.81±0.1	15.05±1.2
Protein Content	80.17±1.7	88.79±1.5	75.29±1.7

(a) (b) (c)

Figure 1. Results of Gelatin Extraction from Several Types of Fish Skin (Note: (a) Catfish Skin Gelatin (b) Tilapia Skin Gelatin (c) Tuna Skin Gelatin (Nurilmala et al., 2021)

The physiological characteristics of gelatin determine its quality (Iqbal *et al.,* 2015). The quality of raw materials, pH, the presence of organic matter, extraction techniques, temperature, and preservative concentrations affect the characteristics of gelatin. Species, types, age, types of animal feed, and storage conditions of raw materials are additional components that affect the properties of gelatin and its production process (Awwaly, 2017). The characteristics of gelatin such as yield, viscosity, and gel strength differ in each study derived from fish skin and bones, according to the results of observations. Table 2 shows a list of studies on the characteristics of gelatin extracted from fish skin and bones.

Table 2. Characteristics of Gelatin in Fish Skin and Bones (Asmawati, 2023)

Reference	Types of Fish	Characteristics of Gelatin Extraction	
		Yield (%)	Gel Strength (g)
Fish Skin			
Tabarestani *et al.,* (2010)	Rainbow Trout	9.35	459.00
Prommajak & Raviyan (2013)	Catfish	5.60	213.75
Wulandari *et al*., (2013)	Striped snake fish	3.53	202.90
Hermanto *et al.,* (2014)	Catfish	11.60	416.90
Saputra *et al*., (2015)	Pangas catfish	11.94	140.57
Azara (2017)	Grouper	6.99	19.73
Fan *et al*., (2017)	Salmon	3.70	102.00
Gunawan *et al*., (2017)	Mackerel	5.90	328.57
Kumar *et al*., (2017)	Grouper	2.75	193.40
Nurilma *et al*., (2017)	Yellowfin Tuna	17.00	178.90

Reference	Types of Fish	Characteristics of Gelatin Extraction	
		Yield (%)	Gel Strength (g)
Febryana *et al*., (2018)	Feather fish	3.29	50.25
Nasution *et al*., (2018)	Catfish	14.30	141.50
Agustini (2020)	Nile Tilapia	12.98	132.54
Nugraheni *et al*., (2021)	Triggerfish	8.69	294.47
Haris *et al.,* (2021)	Striped snake fish	7.18	169.45
Fish Bone			
Efendi *et al*., (2012)	Milkfish	16.19	70.50
Wulandari *et al*., (2013)	Catfish	3.53	202.90
Iqbal *et al*., (2015)	Nile Tilapia	2.90	136.43
Hidayat *et al*., (2016)	Tuna	8.10	372.21
Minah *et al*., (2016)	Tuna	8.44	262.50
Panjaitan (2016)	Skipjack tuna	5.03	167.84
Ridhay *et al.,* (2016)	Skipjack tuna	7.31	47.60
Singkuku *et al*., (2017)	Tuna	2.50	62.45
Istiqlaal (2018)	Mackerel	3.21	102.51
Mahmuda *et al*., (2018)	Mackerel	8.80	151.45
Nurhaeni *et al*., (2018)	Mackerel	6.44	44.45
Pertiwi *et al*., (2018)	Pangas catfish	6.14	364.19
Ariyanto *et al*., (2022)	Mackerel	6.61	51.55

Application of Gelatin from Fish Waste

The fishing industry produces abundant waste, especially in the form of fish bones, skin, and scales. In Indonesia, the amount of fish waste reaches millions of tons per year. This waste is generally dumped into the sea or buried in landfills, causing environmental pollution. Gelatin is widely used for making glue (Sulistyanto *et al.*, 2015), cosmetic products, emulsifiers in the food industry, and pharmaceutical products (Shahidi *et al.*, 2019). Gelatin from fish bone waste can be obtained by soaking in an acid solution. The goal is to convert collagen and dissolve minerals so that the fish bones become soft (Yuliani & Marwati, 2015) Some examples of the application of gelatin from fish waste for food Table 3.

Table 3. Application of Gelatin from Fish Waste

No.	Application of Gelatin from Fish Waste	Reference
1.	Gelatin from fish scales can be used as a formulation ingredient in food products such as syrup thickeners, jelly candy, confectionery, ice cream and noodle thickeners	(Junianto,2024)
2.	The addition of gelatin from tilapia fish bones in pineapple syrup, with different soaking times and different concentrations, had a significant effect on pH and viscosity	(Istiqomah,2023)
3.	Gelatin from fish scales is used as a medicinal capsule product	(Al-Nimry *et al.*, 2021)
4.	Gelatin is applied as a gelling agent in many cosmetic products including face creams, body lotions, shampoos, hair sprays, sunscreens, and bath salts and bubbles	(Elgadir *et al.*, 2005)
5.	Investigation of changes in antioxidant activity in skin tissue and collagen fiber structure using ultraviolet radiation-induced skin photoaging	(Chen & Hou, 2016)

No.	Application of Gelatin from Fish Waste	Reference
6.	Gelatin from skipjack tuna (K. pelamis) skin was extracted using acid (STG-A), enzyme (STG-E), and hot water (STG-H) methods, and its physicochemical properties showed that the gelatin was similar to type I collagen used in cosmetic products.	(Zhang *et al.*, 2022)

DISCUSSION

Gelatin is a derivative product of collagen protein found in animal skin and bones. The manufacturing process involves collagen denaturation, which is the breakdown of its protein structure. The level of gelatin hydrolysis is influenced by the cross-linking between the peptide chain and the reactive amino acid groups. (Kilcast & Subramaniam, 2000) explained that gelatin has unique properties, namely it can form a gel when mixed with water and heated at a temperature below 35 ° C, which corresponds to human body temperature. Gelatin on the market is classified into two commercial types, namely type A and type B. Gelatin is an extraordinary source of protein, with a protein content reaching 84-86% in dry gelatin with a water content of 8-12%. The fat content is very low, almost nonexistent, and the minerals range from 2-4%. Interestingly, gelatin contains 9 of the 10 types of essential amino acids needed by the body, only lacking one essential amino acid, namely Treptophane (Hastuti & Sumpe, 2007).

The most abundant protein in animal tissue is collagen, which is the parent compound of gelatin. Collagen represents almost 30% of the total protein in animal tissues (Pati *et al.*, 2010). Collagen has been found in various genetic forms and to date about 27 types of collagen have been identified. Type I collagen is found abundantly in connective tissues, such as tendons, bones, and skin. Type II collagen is only found in cartilage tissue (Morales et al., 2000); (Schrieber & Gareis, 2007). Collagen types I and V have been isolated from squid muscle (Morales et al., 2000a), fish bladder ((PIEZ & GROSS, 1960); (Eastoe, 1957); (Rajendan *et al.*, 2010), fish scales (Nagai *et al.*, 2004), and fish skin ((Sadowska *et al.*, 2003); (Senaratne et al., 2006). (Kubota et al., 2003) found that type III collagen was not found in the amounts that can be found in the above-mentioned fish species. Similar findings were found in a study (Morales *et al.*, 2000) where only type I and V collagens were found from various cephalopods. The amount of type III collagen is highly dependent on the age of the animal; thus, the skin of young animals can contain up to 50% type III collagen, but then decreases to 5-10% with age (Schrieber & Gareis, 2007).

Challenges and Prospects of Utilizing Fish Waste for Gelatin Production

Utilizing fish waste for gelatin production has several challenges that need to be overcome, including:

a) Availability of Raw Materials: Inconsistent supply: The amount and quality of available fish waste can vary depending on the season, type of fish, and fish processing activities. This can make it difficult to ensure a stable supply of raw materials for gelatin production. Raw material quality: Fish waste can be contaminated with various impurities, such as bacteria, heavy metals, and chemicals. These impurities must be removed before being processed into gelatin so as not to endanger consumer health.
b) Production Process: Complex process: The production of gelatin from fish waste involves several complex steps, such as cleaning, collagen extraction, hydrolysis, and purification. This process requires time, energy, and relatively high costs. Low extraction efficiency: The efficiency of collagen extraction from fish waste is still relatively low, resulting in low gelatin yields. This can increase the cost of gelatin production. Gelatin quality: The quality of gelatin produced from fish waste is still inconsistent and often does not meet industry standards. This is due to variations in the quality of raw materials and production processes.

c) Market Competition: Conventional gelatin: Gelatin made from pork or beef skin and bones still dominates the market and has a cheaper price than fish gelatin. Lack of consumer awareness: Consumers are still not very familiar with fish gelatin and its benefits. This can hinder market demand for this product.
d) Regulations and Standards: Unclear regulations: In some countries, regulations on the use of fish waste for gelatin production are still unclear. This can create uncertainty for business actors and hinder the development of the fish gelatin industry. Quality standards: The quality standards for fish gelatin that are not yet uniform in various countries can complicate international trade in this product.
e) Environmental Impact: Waste processing: Fish waste processing for gelatin production can produce liquid and solid waste that has the potential to pollute the environmentEnergy utilization: The gelatin production process requires quite a lot of energy, so it can increase greenhouse gas emissions and contribute to climate change.

CONCLUSION

Fish waste can be utilized into useful products with high economic value. The most widely studied fish waste and utilized as an alternative to gelatin products are fish bones and scales. Research and development of the utilization of fish waste into gelatin needs to be increased.

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