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Study of the Potential and Critical Point Milkfish Bone-Based Gelatin as an Alternative to Substitute Non-halal Gelatin

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ABSTRACT

Collagen partially hydrolyzes to produce gelatin that functions as a gelling and non-gelling agent for various industries. Currently, Indonesia cannot produce its own gelatin, so to meet its needs, Indonesia imports 100%. However, many imported gelatins are still made from pork, so they need to be replaced to ensure that the gelatin is halal. This paper discusses the potential and critical point milkfish bone-based gelatin to substitute fork-based gelatin. The general process for making gelatin from milkfish bones involves extracting, drying, demineralizing, degreasing, and determining the gelatin yield. Brackish water fish collagen, including milkfish, contains approximately 12–14 kDa parvalbumin, suggesting the potential for allergic reactions among consumers. Meanwhile, the critical point for halal gelatin extracted from milkfish bones is the origin of the milkfish bones and the use of citric acid as an extractor. Although there are still weaknesses, gelatin from milkfish can replace pork-based gelatin, and it can have a positive impact on the Indonesian economy by reducing gelatin imports.

Keywords: *Critical Point, Food, Gelatin, Halal, Milkfish.*

1 Introduction

Indonesia is a country with a large Muslim population. In the first semester of 2023, 279.1 million people lived in Indonesia, over 87% of whom embraced Islam, according to the Ministry of Home Affairs' Directorate General of Population and Civil Registration [1]. Food

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is one of the main human needs in Indonesia, and as a country with a very large Muslim population, Indonesia has a strong connection between the food market and the principles of halal and haram law that govern Muslims. In the Qur'an Surah Al-Baqarah 168, we are commanded to consume halal and thayyib [2].

Collagen undergoes partial hydrolysis to produce gelatin. Gelatin is a soluble protein that can be used as a gelling or nongelling agent. Gelatin can be found in food goods and in nonfood items like films, cosmetics, medicinal capsules, and medications. Therefore, it is important to introduce such methods to the community. Based on the Badan Pusat Statistik 2020 data, Indonesia currently imports approximately 4800 tons of gelatin per year, primarily from Europe and America to meet its needs.

Currently, gelatin is still widely produced from pork bones. This is a problem for most Indonesians. As Allah SWT's Firman [3] in Q.S. Al-Maidah verse 3:

حُرِّمَتْ عَلَيْكُمُ الْمَيْتَةُ وَالدَّمُ وَلَحْمُ الْخِنْزِيْرِ وَمَآ اُهِلَّ لِغَيْرِ اللّٰهِ بِهٖ وَالْمُنْخَنِقَةُ وَالْمَوْقُوْذَةُ وَالْمُتَرَدِّيَةُ وَالنَّطِيْحَةُ وَمَآ اَكَلَ السَّبُعُ اِلَّا مَا ذَكَّيْتُمْۗ

Meaning:

" It is forbidden for you to (eat) carcasses, blood, pork, and animals that are slaughtered not in the name of Allah, those who are suffocated, those who are struck, those who are beaten, those who fall, those who are horned, and those who are pounced upon by wild beasts, except those that you have slaughtered. ..."

In addition to religious reasons, halal gelatin substitution plays a role in the economic sector. The Fiscal Policy Agency of the Ministry of Finance (BKF) at the 7th Annual Islamic Finance Conference (AICIF) stated that the halal industry is growing positively in relation to various global challenges. In 2021, 1.9 billion Muslim people will be living in the world, spending 2 trillion in halal products. This spending grew by almost 9% per year and is expected to increase to USD 4.96 trillion by 2030. Therefore, the halal industry is a promising commodity to be developed.

Based on the description above, the right solution is to replace raw materials for making gelatin from nonpork ingredients so that gelatin can be consumed by Muslims. In addition, to maximize the economic potential of Halal gelatin, its production must meet Standard Nasional Indonesia (SNI), one of which is the general requirements for halal food [4]. An alternative source of gelatin production is fish skin and bones, one of which is milkfish (*Chanos chanos* Forskal). Milkfish bone has a high protein content, making it a raw material for fish protein hydrolysate. The protein content of milkfish can be processed into a protein hydrolysate, which can be later processed into gelatin. Gelatin is primarily derived from collagen found in the skin and bones of milkfish, making these parts valuable for gelatin production due to their collagen-rich nature. Additionally, its production in Indonesia is also high.

Kalanganyar Village, Sidoarjo, is a milkfish fishing tourist area that provides milkfish spine removal services. Every day, spine pullers work on up to 30 milkfish [5]. With the number of fishing in Kalanganyar village, which provides milkfish bone removal services of more than

20 fishing with 1 fishing has 10 to 15 people to remove milkfish bones, it can be estimated that the results of the milkfish spine removal service produce quite a lot of milkfish bone "waste" [6] [7]. We can integrate the tourism business with the production of halal gelatin to anticipate the critical point of making nonfatal gelatin from milkfish bones. Therefore, this study aimed to examine the potential and critical point of gelatin production materials processes from milkfish bones in replacing imported gelatin, whose raw materials mostly come from pigs [8].

2 Materials and Methods

In general, this review was carried out as a study of a journal study on the analysis of gelatin needs in Indonesia, the use of gelatin, the manufacture of gelatin, a special study on the halal process of previous gelatin and its substitutes, and an analysis of the production of halal gelatin from milkfish bones. Therefore, it is hoped that this review can be used as a reference for the preparation of halal gelatin from milkfish bones.

3 Demand for Gelatin in Indonesia

In Government Regulation of the Republic of Indonesia 86/2019 related to food safety, gelatin is commonly used as an additional raw material. Gelatin is used as an additive in food products because it has distinctive properties, namely, it can be reversible; it is initially in the form of a sole, can be changed into a gel form, expands in cold water, can form a film, and can affect the viscosity of an ingredient [9]. Gelatin, which has water-soluble properties, can be easily applied in various fields of the food and nonfood industries [10] [11]. The usefulness of gelatin, which can be used in various industrial fields, including food and non-food, makes the need for gelatin even higher. However, gelatin production in Indonesia has not yet been developed. The industry that produces gelatin in Indonesia currently has no gelatin producers. So far, there are only companies engaged as distributors and companies that are under development to produce gelatin from cowhide. The development of cowhide as a raw material for gelatin can compete with the handicrafts and leather cracker industries [11].

The increasing demand for gelatin in Indonesia has led Indonesia to import gelatin from various countries. The gelatin needs that are met in Indonesia come from imported products due to the availability of gelatin in the country. In the data on gelatin imports to Indonesia according to data from the Central Statistics Agency (2020), from 2016 to 2019, the number of gelatin imports increased annually. The increase in the annual number of gelatin imports indicates that the demand for gelatin in Indonesia is also increasing. It can also be seen from data from the Central Statistics Agency (2023) that gelatin imports amounted to 2.45 million kg until November 2023, with a value of USD 20.77 million [12].

4 Functions of Gelatin

Both the food and nonfood industries in Indonesia use gelatin as an additional raw material. Table below shows several functions of gelatin in a various industry [13].

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Table 1. Functions of Gelatin in Several Industries

No	Sector	Functions
1.	Food Industries	- Stablizer in ice cream production - Viscosity enhacer and binders - Emulsifier and thickener - Muscle grower precursor of keratin - Nutritious food
2.	Photography	- Photoresist
3.	Pharmaceutical	- Material of soft capsule - Material of capsule shells - Tablet
4.	Engineering	- Additional material for glue production - Paper - Paint - Adhesives
5.	Cosmetics	- Material of lip balm - Shampoo - Soap

Standardization in the gelatin industry in Indonesia can be observed in terms of fat content, protein content, gel strength, and Ph and metal residue content. The fat content requirements in accordance with SNI (Standar Nasional Indonesia) are not more than 5% as a quality requirement for gelatin; the low-fat content owned by gelatin can prove to be good quality gelatin; the acquisition of gelatin with low fat content is carried out from the process of removing fat and minerals properly. The low-fat content in gelatin allows it to be stored for a long time without causing an odor or a rancid taste.

Gelatin has a high protein content. High-protein gelatin contains numerous amino acid residues that allow the protein to develop into a long polypeptide chain. Strong bonds between protein molecules also impart gelatin with high protein content with high binding power to water. A high protein content of gelatin indicates a good level of gelatin content.

Gel strength is a key factor in determining the properties of gelatin. The application of gelatin to certain culinary or nonfood products can be determined by the strength of the gel. Gel strength is a measure of gelatin's ability to transition between the gel and sole phases and vice versa. The material concentration and hardening period affect the physical characteristics. The standard SNI for gelatin is 50–300 g. The collagen protein extraction process significantly affects the quality of the gelatin produced. This is because using soaking agents at high concentrations—both acidic and alkaline—can affect gel strength.

pH affects the way gelatin is used in an item. In chromatography, paints, meat products, and medicines, gelatin is used at neutral pH. Gelatin with a low pH is used to make juices, jellies, syrups, and other products. The type of immersion solution used to extract gelatin significantly affects the pH. The pH ranges from 4.5 to 6.5 is the SNI standard for gelatin pH. The extraction method used affects the gelatin pH. The solvent used during immersion

determines the final pH. High and low pH are produced by alkaline and acid processes, respectively. The metal residue content was determined by determining the presence of arsenic and sulfite. According to SNI, the metal residue content in gelatin is from arsenic, which has a maximum content of 2 ppm, and in sulfites, a maximum content of 1000 ppm [14].

5 Making Gelatin

In general, the ingredients used for the manufacture of gelatin are substances that are high in collagen, such as the skin and bones of pigs, fish, cows, and other animals, which can theoretically be used to make gelatin. However, it is worth mentioning that most of the gelatin used today comes from pigskins because of its easy access to raw materials, economic value, and processing efficiency. Another drawback, in contrast to gelatin made from pigskin, which is more affordable with the same level of quality, gelatin made from the skin and bones of cows or other large animals requires less washing water and neutralization (chemicals), as well as a longer process. Therefore, gelatin from pig skin is more widely used than that from other skins from technological and financial perspectives.

There are two methods for producing gelatin: acid and alkaline processes. The difference between acid and alkaline processes is observed in the embalming process. The final product has two types: types A and B. The difference between these types of gelatins is determined by how they are processed. To make type A gelatin, the raw material is soaked in a solution of inorganic acids like phosphoric acid, sulfuric acid, hydrochloric acid, and sulfuric acid. To make type B gelatin, the raw materials are soaked in lime water. This process is known as the "alkaline process". The main gelatin production is carried out in three stages. First, the raw material must be prepared by removing the non-collagen portion of the raw material with or without reducing the bonds between the collagens. Next, the collagen is converted into gelatin, and finally, the gelatin is purified and taken in a dry form. The process of making gelatin from bovine bone collagen consists of cleaning and reducing bone size, drying, demineralization, liming, extraction, thickening, drying, and size reduction. The stages of gelati processing include reducing the size of the raw materials and soaking, washing, heating, compacting, cooling, and drying [15].

The gelatin process is as follows:

1. After the raw materials are free from the remaining meat that adheres to them, degreasing is carried out. This process was performed by cooking for 3 h at a temperature of 32-80°C and then reducing the size by 2-3 cm. During this process, continuous stirring is carried out to improve separation.
2. The bones were then soaked in a 5% HCI acid solution for 10 days. This acidic solution is called ossein, and bones are separated by filtration. Next, washing with water is performed.
3. Ossein resulting from acid treatment was soaked in 5% HCI for 10-48 hours. Occasionally, stirring is required during soaking. After that, the ossein is neutralized by washing with water, using a dilute NaOH solution, and washing with water.
4. After that, the ossein is ready to be extracted. To do this, put the ossein in a goblet glass or Erlenmeyer, and add water. The mixture was then heated at intervals of 55-65

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5. °C for 4 h, during which the gelatin solution and ossein residue were separated by filtration. The remaining ossein was heated again at 65-75℃ for another 4 h, during which the gelatin solution and remaining ossein were separated by filtration. Residual ossein: After collecting gelatin, filtration is repeated.
6. After preparation, the gelatin solution is still diluted. The gelatin solution was solidified by cooling in a cooling chamber.
7. The gel (gelatin), which has taken a solid shape, then dries. The oven was used at 50℃–60°C to dry the gelatin until the gelatin moisture content was approximately 9%–12%.

6 Potential of Milkfish Bone-Based Gelatin

Gelatin is a product of animal protein decomposition and has many benefits in the food and nonfood sectors. Most gelatin products are derived from animals, such as pigs and cows, and it is still unclear whether gelatin products are halal due to the slaughter of animals that are absolutely forbidden or slaughtering methods that are not in accordance with Islamic law. Muslims and Hindus still debate the use of beef and pork gelatin as food and nonfood ingredients. Indonesian fishery products, including fish bones, have great potential as raw materials for gelatin in the manufacture of halal capsule shells. Therefore, to obtain standardized materials for use as food and nonfood ingredients, an assessment of the characteristics and preformulation of fish bones is necessary [16].

The process of making gelatin from milkfish bones [17] is, as follows:

Extraction process

1. Degreasing
   After cleaning the remaining meat and fat from running water, milkfish bones are soaked for 30 min in water at 60 ℃-70℃. Cut into small pieces and dry.
2. Demineralization
   The milkfish bones are then soaked in citric acid solution. During the soaking process, milkfish bones are soaked for 48 h to remove minerals and then washed with aqueous water to pH 5.
3. Extraction and Drying
   The demineralized product was extracted in a water bath using distilled water at 70°C for 6 h, cooled, and filtered using filter paper. Dried in an oven at 50°C for 24 h. Next, the gelatin was ground with a grinder. The gelatin was then weighed to determine its yield, after which a physical and chemical analysis of the gelatin was conducted.
4. Rendemen Yield
   The yield was obtained by comparing the dry weight of the gelatin produced with the weight of the fish bones.

Physical tests of gelatin of milkfish bones showed that the citric acid concentration increased viscosity, whereas water absorption decreased when the pH was in an acidic atmosphere. The presence of noncollagen components, temperature, molecular weight, and protein structure affect the viscosity of gelatin [18]. Gelatin, which has a high hydroxyproline content, exhibits very high viscoelastic properties. The physical

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characteristics of gelatin included a viscosity of fish bone gelatin of 5.5 cP and a citric acid concentration of 7%. This result meets the quality standards of gelatin because it is in the range of 1.5-7.5 cP. For the water absorption and pH parameters, all concentration variations met the standard in the range of 3.8-5.5 [19].

A chemical characteristics test on milkfish bone gelatin showed that the moisture content and gelatin ash met the [20], with a maximum ash content of 3.25% and a maximum gelatin moisture content of 16%. Protein levels increase due to more soluble amino acid bonds during extraction, resulting in increased protein levels in gelatin products. The yields obtained ranged from 84 % to 90 % for commercial gelatin raw materials, slightly lower than the SNI standard. However, gelatin made from milkfish bones can be used instead of gelatin, which is usually made from pork skin and cow bones.

7 Gelatin Allergen Analysis of Milkfish Bones Gelatin

There is a slight potential that parvalbumin, namely the calcium-binding protein β-parvalbumin, will contaminate fish collagen [21]. Based on [22], brackish-water fish and freshwater fish have parvalbumin contents ranging from 12 to 14 kDa, which milkfish is estimated to have a content that is not too different but cannot be characterized between α or β form. The allergenicity of fish collagen cannot be diminished by cooking. Additionally, fish collagen is resistant to pepsin, which facilitates its connection with immune cells. Compared with children and adolescents, adults bind to fish collagen more frequently than IgE does. Monosensitization to fish collagen and its derivatives is possible. There is a risk of allergic responses, ranging from mild to severe, when using fish collagen and its derivatives. Common clinical symptoms include rhinitis, oral allergy syndrome, diarrhea, abdominal pain, angioedema, urticaria, asthma, and, in extreme situations, potentially fatal anaphylactic reactions. Fish collagen allergies and their derivatives have not been reported in Indonesia, and there is no accepted protocol for BPOM (Indonesian Food and Drug Supervisory Agency) to identify fish collagen and its derivatives as allergies.

8 Traceability Study of Halal Milkfish Bones Gelatin

To make gelatin from milkfish bones, you need large milkfish bones with a back length of more than 18 cm, a diameter of more than 5 mm, and a weight of more than 7 grams. The two chemicals used to make gelatin are hydrochloric acid (HCl) and Aquadest [23].

According to the fatwa of the Indonesian Ulema Council (MUI), there are several critical points that need to be considered in making gelatin from milkfish bones, this is to ensure that the products produced are halal. Make sure the milkfish to be used is milkfish that comes from halal sources and is not contaminated with haram or unclean ingredients during cultivation, catching, weeding, and storage. This includes avoiding contact with substances such as pork or alcohol and ensuring adherence to halal standards throughout the entire production chain. It can be seen from Table 1. that the critical point of the three studies was found in the main raw material, namely milkfish bones. The next critical point is the gelatin extraction process, in which additives or auxiliary ingredients such as acids or bases are used. These additives must be ensured to be halal and must not use ingredients that come from haram or unclean sources. In this case, strict and appropriate procedures are required

to prevent cross-contamination with non-halal products. Not only the main raw materials but additional raw materials need to be ensured halal. However, in the processing, packaging, storage, and distribution of gelatin from milkfish bones, it is also necessary to consider the halal [24].

Table 2. Traceability Study of Milkfish Bones Based Gelatin

Research	**Material Composition**	**Explanation** [25]
[26] With The Title: "Ekstraksi dan Penggunaan Gelatin dari Limbah Tulang Ikan Bandeng *(Chanos chanos* Forskal) sebagai Emulgator dalam Formulasi sediaan Emulsi." or in English "Extraction and Use of Gelatin from Milkfish Bone Waste (*Chanos chanos* Forskal) as Emulgator in Emulsion Formulations"	Milkfish bones	Critical Point, ensure bones are sourced from halal environments
	Citric Acid 9%	Critical Point, check for halal certification and fermentation media
	K_2SO_4	Check for halal certification and permissible limits to consume in BPOM
	$CuSO_4$	No data, check for permissible limits to consume in BPOM
	H_2SO_4	Positive list, check for permissible limits to consume in BPOM
	NaOH	Positive list, check for permissible limits to consume in BPOM
	H_3BO_3	Positive list, check for permissible limits to consume in BPOM
	Gliserin	Syubhat, the way the animal is slaughtered, and the animal used. If the source of the fat is a haram animal, it is obviously not halal.
	Gum arab	Positive list, check for permissible limits to consume in BPOM

Research	**Material Composition**	**Explanation** [25]
	Metil paraben	Positive list, check for permissible limits to consume in BPOM
	Propil paraben	Positive list, check for permissible limits to consume in BPOM
	Oleum menthae piperitae	Check for halal certification
	Oleum lecoris aselli (fish oil)	Check for halal certification
	Aquades	Positive list
[27] With the title: "Efektivitas Penggunaan Asam Sitrat dalam Pembuatan Gelatin Tulang Ikan Bandeng (*Chanos-chanos* Forskal)." or in English "Effectiveness of Citric Acid in the Preparation of Milkfish Bone Gelatin (*Chanos-chanos* Forskal)."	Milkfish bones	Critical Point, ensure bones are sourced from halal environments
	Citric Acid 9%	Critical Point, check for halal certification and fermentation media
	Aquades	Positive list
	H_2SO_4	Positive list, check for permissible limits to consume in BPOM
	Na_2SO_4	Positive list, check for permissible limits to consume in BPOM
	NaOH	Positive list, check for permissible limits to consume in BPOM
	Zinc	Positive list, check for permissible limits to consume in BPOM
	HCl	Positive list, check for permissible limits to consume in BPOM
	Saturated borate acid	Positive list, check for permissible limits to consume in BPOM

Research	**Material Composition**	**Explanation** [25]
	Red Methyl	There's an alcohol to make red methyl so it's haram to consume
[28] With the title: "Pembuatan Gelatin dari Tulang Ikan Bandeng dengan Metode Ekstraksi dan Variasi Konsentrasi Asam Sitrat" or in English "Making Gelatin from Milkfish Bone by Extraction Method and Variation of Citric Acid Concentration"	Milkfish Bones	Ensure bones are sourced from halal environments
	Aquades	Positive list
	Citric Acid	Critical Point, check for halal certification and fermentation media

9 Conclusion

Potential use of fish bone gelatin from milkfish as an alternative to non-haram gelatin in Indonesia, a country with a Muslim majority. Gelatin is widely used in various industries, including food, pharmaceuticals, and cosmetics. The production of gelatin from fish bones can provide a sustainable alternative to the use of gelatin from pork bones, which are currently imported from Europe and America. The process includes extraction, demineralization, and drying. Fish bone gelatin products have been proven to meet quality standards and have potential application in the food and nonfood industries. The traceability of halal gelatin from fish bones is important for halal certification and meets the needs of Muslim consumers in Indonesia. The study highlights the potential of fish bone gelatin as an alternative to non-halal sources and the importance of developing local supply chains for halal gelatin production, which can meet the needs of Indonesia's Muslim-majority population.

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