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EXPLORING THE POTENTIAL OF HALAL GELATIN FROM CHICKEN BY-PRODUCTS: A REVIEW

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ABSTRACT

Gelatin is a product of the partial hydrolysis of collagen from bones, skin, and animal tissues. Gelatin is frequently used in the food industry. However, Indonesia itself is not a gelatin-producing country. Indonesia's gelatin needs are dependent on imports from other countries. This activity is highly sensitive because the raw materials for gelatin typically consist of pig and its byproducts, whereas Indonesia is a predominantly Muslim-populated country. This article review discusses the potential of chicken byproducts as a halal alternative to gelatin from related journals published over the past decade. Gelatin produced from chicken byproducts has varying characteristics, including gel strength, gelling point, melting point, and viscosity. Chicken byproducts' gelatin can fill all categories of gelatin, ranging from low to high gel strength. This makes it applicable to various industries, particularly in the food and pharmaceutical sectors. However, to ensure its halal status, it is necessary to verify that the byproducts used as the raw material for gelatin originate from halal chicken slaughter.

Keywords: Alternative, By-Product, Halal, Pre-Treatment, Poultry

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INTRODUCTION

Gelatin is a product obtained from the partial hydrolysis of collagen, which originates from bones, skin, and connective tissues of animals, including fish and poultry (GMIA, 2019). The utilization of gelatin in industry is very extensive, leading to a continuous increase in demand. The food industry uses about 59% of the total global gelatin production, the pharmaceutical industry accounts for 31%, and other industries for 10% (Mohebi & Shahbazi, 2017). In the food industry, gelatin functions as a gelling agent, thickener, stabilizer, and so forth. However, by 2035, gelatin production is projected to be insufficient to meet global demand due to the imbalance between availability and consumption (Prokopová, Gál, Mokrejš, & Pavlačková, 2022). In Indonesia, the need for gelatin is still dependent on imported products from countries such as Australia, Argentina, China, Germany, Brazil, India, Japan, and France (BPS, 2016). As of November 2022, gelatin imports in Indonesia had reached 2.45 million kg with a total value of 20.77 million USD (BPS, 2023). Limited sources of gelatin also contribute to the shortage of gelatin production in Indonesia.

To date, the largest sources of gelatin are mammals such as pigs and cattle (Zhang et al., 2020). This raises concerns and doubts among Muslims and Hindus regarding the consumption of gelatin-derived products. Therefore, alternative sources of gelatin need to be developed. Numerous studies on alternative gelatin have been conducted, such as gelatin from catfish skin (Putri, Hermanianto, Hunaefi, & Nurilmala, 2023), Nile tilapia bones (Istiqomah & Sugiharto, 2023), brownstripe red snapper, swanggi, and kurisi fish skin and scales (Widiyanto, Uju, & Nurilmala, 2022), among others. These studies indicate that alternative gelatin sources still hold potential for further development. However, fish-derived gelatin and its derivatives still face limitations, such as unpleasant odor (Mokrejš et al., 2019).

One potential alternative source of gelatin is poultry. The increasing consumption of poultry meat also raises the volume of by-products (Prokopová, Gál, Mokrejš, & Pavlačková, 2023). One of the most consumed types of poultry in Indonesia is chicken (BPS, 2016). By-products from chicken processing include the head, skin, feet, gizzard, intestines, and bones. These by-products contain protein, making them potential alternative sources of gelatin (Prokopová et al., 2023). The purpose of this review paper is to elaborate on the potential of gelatin derived from chicken processing by-products.

METHODOLOGY

The method used in this review article is a literature study by collecting relevant journals published within the last 10 years (2013–2023). Literature searches were conducted through search engines such as Google Scholar, as well as several scientific journal providers such as Science Direct, PubMed, MDPI, SpringerLink, and others using the keywords "chicken gelatin" and "gelatin ayam."

RESULTS & DISCUSSIONS

Gelatin from Chicken By-Products

Indonesia is the second-largest producer of chicken livestock after China. In 2021, chicken production in Indonesia reached 3.48 billion heads (Statista, 2023). Commonly consumed chicken parts include meat, carcass, and giblets (heart, liver, and gizzard). Other parts that are usually not consumed (by-products) include feathers, head, neck, feet, and entrails other than giblets (Fathoni, Tanwiriah, & Indrijani, 2017). Table 1 presents several studies from the last 10 years on the extraction and characterization of gelatin from various chicken by-products. The gelatin yield obtained varies and can be influenced by several factors, such as raw material, temperature, and extraction time (Erge & Zorba, 2018). Chicken skin and intestines tend to produce lower yields, whereas the head and gizzard parts have been reported to generate relatively high yields (Ab Rahim, Ahmad, & Ab Rahim, 2021; Du, Khiari, Pietrasik, & Betti, 2013; Ee et al., 2019; Gál et al., 2020; Gumilar & Pratama, 2018; Mohammadnezhad & Farmani, 2022; Prokopová et al., 2023; Saenmuang, Phothiset, & Chumnanka, 2020).

Table 1. Studies Related to Gelatin from Chicken By-Products

Source	Extraction method	Gelatin Yield (%)	References
Skin	Alkali + acid	16±0.91	(Mhd Sarbon, Badii, & Howell, 2013)
	Alkali + acid	16.48 – 21.7	(Prihatiningsih, Puspawati, & Sibarani, 2014)
	Alkali + acid	6.6±0.87 – 7.23±1.15	(Saenmuang et al., 2020)
	-	3.53	(Mohammadnezhad & Farmani, 2022)
Bone	Acid	8.53±1.39 - 15.4±0.94	(Yuliani, Maunatin, Jannah, & Fauziyyah, 2019)
	Acid	2±0.31 - 8.35±0.49	(Kadarani & Jannah, 2022)
Feet	Acid + *ultrasound*	12.37 - 12.64	(Widyasari & Rawdkuen, 2014)
	Acid	4.65±0.07 – 5.31±0.05	(Choe & Kim, 2018)

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Source	Extraction method	Gelatin Yield (%)	References
	Alkali + endoprotease enzyme	17 – 39.1	(Mokrejš, Mrázek, Gál, & Pavlačková, 2019)
	Alkali	9.53±2.33 – 10.59±1.65	(Saenmuang et al., 2020)
	Alkali + acid	22.18±1.08 – 33.65±1.3	(Ab Rahim et al., 2021)
	Alkali + acid	16.95 – 17.23	(Rather et al., 2022)
Head	Alkali	52.29	(Du et al., 2013)
	Alkali + acid	7.67±0.52 – 10.29±0.36	(Ee et al., 2019)
	Alkali + proteolytic enzyme	20.4 – 35.8	(Gál et al., 2020)
	Alkali + acid	20.06±0.36 – 32.1±0.45	(Ab Rahim et al., 2021)
Intestine	Acid	0.58 - 4.33	(Gumilar & Pratama 2018)
Gizzard	Alkali + proteolytic enzyme	59.8 – 70.6	(Prokopová et al., 2023)

Gelatin Extraction from Chicken By-Products

Gelatin can be classified into two types, determined by the pretreatment applied during its production process. Type A gelatin, with an isoionic point of 6–9, is obtained from precursors treated with acid (commonly pH 1.5–3.0), while Type B gelatin, with an isoionic point of 5, is obtained from precursors treated with alkali (commonly pH 12) (Hanani, 2016). Various studies have analyzed the comparison of gelatin yields between acid and alkali methods, as shown in Table 1.

The use of a single method has been widely carried out in previous studies, such as the use of the acid method for extracting gelatin from chicken bones with various HCl concentrations, where 6% HCl yielded the best results (Windyasmara, Pertiwiningrum, Asmoro, & Afriyanti, 2018). The use of acid solution (0.1 N HCl with pH 2) in extracting gelatin from chicken feet showed that extraction at 65°C produced the best results, with gel strength, viscosity, and melting point values of 359.60±26.95 bloom, 52.45±2.07 Pa.s, and 35.17±0.29°C, respectively (Choe & Kim, 2018).

The use of the single alkali method has also been applied. Chicken skin gelatin extracted with the alkali method showed thermal stability and gel strength that tended to decrease with increasing NaOH concentration (Saenmuang et al., 2020). The use of two different methods, acid and alkali, has also been carried out for extracting gelatin from chicken heads and feet (Ab Rahim et al., 2021). The results showed that the gelatin yield percentage of chicken heads and feet with acid treatment was 32.10% and 33.65%, respectively, whereas with alkali treatment it was 20.06% and 22.18%. Using pH values in the range of 4.3–6.4 showed a consistent pattern, where the melting point of gelatin ranged from 30.4–35.9°C (Ab Rahim et al., 2021).

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Recently, modifications have been made to these two methods, one of which is by combining them. Ee et al. (2019) compared three extraction methods of gelatin from chicken heads with different pretreatments: acid-alkali, acid, and alkali. The results showed that the highest gel strength reached >300 bloom with ash content <1%, the highest gelling point at 25.8–26.0°C, and the melting point at 30.8–32.3°C. The best quality gelatin from chicken heads was obtained in descending order using the acid-alkali and acid methods, while the lowest quality was obtained with the alkali extraction method (Ee et al., 2019). The acid-alkali extraction method was also applied for gelatin extraction from chicken feet (Rather et al., 2022). The results showed that at pH 5.14–5.23, the melting point was 23.10–25.10°C, gel strength exceeded 300 bloom, and ash content was <1% (Rather et al., 2022).

Research continues to develop methods for producing gelatin that are simpler yet yield higher quality. Alkali treatment with the addition of enzymes can be applied with good results. The use of alkali solution as pretreatment combined with endoprotease enzymes in the extraction of chicken feet gelatin showed that gelatin gel strength reached 320 bloom, ash content <2%, and viscosity 7.3 mPa.s (Mokrejš et al., 2019). The use of enzymes was also applied to gelatin extraction from chicken heads with alkali pretreatment and the addition of proteolytic enzymes (Gál et al., 2020). The results showed melting points ranging from 34.5–42.2°C, gel strength reaching 355 bloom, ash content ranging from 2.12–3.92%, and viscosity up to 9.5 mPa.s. Treatment with alkali and the addition of protease enzymes was also applied to the extraction of gelatin from chicken gizzards (Prokopová et al., 2023). The results showed that the best treatment yielded a gel strength of 275 bloom, melting point of 33°C, ash content of 0.47%, viscosity of 2.1 mPa.s, and gelling point of 18°C.

Characteristics of Gelatin from Chicken By-Products

The most important characteristics of gelatin are gel strength, viscosity, melting point, and gelling point. Bloom is used as the unit of gel strength. Bloom refers to the weight (in grams) required to depress a standard plunger into the surface of a gel to a specified depth. Gel strength in the range of 200–250 bloom is most preferred for application in food products (Abedinia et al., 2020). Table 2 shows the applications of gelatin based on its gel strength in the food and pharmaceutical industries.

Table 2. Utilization of Gelatin Based on Its Gel Strength
(Source: Abedinia et al., 2020; Prokopová et al., 2023)

Gel Strength (bloom)	**Application**	**Usage**
< 100	Caramel, licorice, marshmallow, meringue	
100 – 200	Beverage industry	Clarifying agent
150 – 250	Dairy products	Syneresis stabilizer
175 – 275	Gelatin desserts, gummy bears	Gelling agent
	Meat products, sausages, broths, canned meats	Emulsion stabilizer, binding agent
200 – 250	Frozen foods	Water loss reduction agent
250 – 400	Hard capsules, soft capsules	
> 400	Medical fibers, contact lens fibers	

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Commercial gelatin has gel strength between 50–200 bloom, viscosity between 2–7 cP, melting point between 60.42–61.71°C, and gelling point between 31.6–31.8°C (Cahyaningrum, Safira, Lutfiyah, Zahra, & Rahasticha, 2021). Table 3 shows the rheological characteristics of gelatin from various chicken by-products, including gel strength, viscosity, melting point, and gelling point.

Table 3. Characteristics of Gelatin from Chicken By-Products

Type of Gelatin	Gel Strength (bloom)	Gelling point (°C)	Melting point (°C)	Viscosity	References
GKuA[a]	355±1.48	24.88±0.27	33.57±0.52	150±18 ml/g	(Mhd Sarbon et al., 2013)
	56.25 – 113.14	-	-	-	(Prihatiningsih et al., 2014)
	239±6.7 - 263.5±3.9	-	55.48±0.87 – 59.42±1.46	-	(Saenmuang et al., 2020)
	291±16	16.5	45.5	22.71±0.04 cP	(Mohammadnezhad & Farmani, 2022)
GTA[b]	368.35±66.16 – 439.09±201.4	-	-	-	(Yuliani et al., 2019)
	224.01 – 265.69±4.39	-	-	-	(Kadarani & Jannah, 2022)
GCA[c]	79.23±11.59 - 185±8.13	-	-	-	(Widyasari & Rawdkuen, 2014)
	-	-	36.38±0.48 – 38.5±0.41	5.12±0,17 – 7.61±0.51 pa.s	(Choe & Kim, 2018)
	206±2 - 325	-	-	3.1 – 7.3 mPa.s	(Mokrejš et al., 2019)
	251±6.7 – 256.6±4.5	-	63.14±0.86 – 69.77±3.89	-	(Saenmuang et al., 2020)
	268±1.1 - 356±1	-	31.6±1.08 – 35.9±1.1	3.35±0.13 – 4.38±0.67 cP	(Ab Rahim et al., 2021)
	251 – 276	-	23.1 – 25.1	49 – 56.1 pa	(Rather et al., 2022)
GKeA[d]	200.4±3.3 – 247.9±5.2	26.2 – 28.2	33.7 – 34.2	-	(Du et al., 2013)

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Type of Gelatin	Gel Strength (bloom)	Gelling point (°C)	Melting point (°C)	Viscosity	References
	38.62±3.25 – 355.77±0.33	15.17±0.29 – 26	24.1±0.17 – 32.3±0.1	-	(Ee et al., 2019)
	113 - 355	-	34.5 – 42.2	1.4 – 9.5 mPa.s	(Gál et al., 2020)
	230.12±0.30 - 320±0.1	-	30.04±0.05 – 32.3±0.7	3.52±0.22 – 4.49±0.15 cP	(Ab Rahim et al., 2021)
GUA[e]	92.21 - 157.48	-	-	-	(Gumilar & Pratama 2018)
GAA[f]	25±1 - 439±6	14±2 - 22±2	29±1 - 37±2	1±0.4 - 3.4±0.3 mPa.s	(Prokopová et al., 2023)

a. Chicken Skin Gelatin
b. Chicken Bone Gelatin
c. Chicken Feet Gelatin
d. Chicken Head Gelatin
e. Chicken Intestine Gelatin
f. Chicken Gizzard Gelatin

Gelatin derived from chicken by-products has varying gel strength, ranging from 25 to 439 bloom. Gelatin from chicken by-products can fit into all categories of gelatin based on its gel strength, namely low gel strength (<100 bloom), medium (100–250 bloom), high (250–450 bloom), and very high (>400 bloom) (Prokopová et al., 2023). Most chicken gelatin in the studies conducted meets the gelatin gel strength standards set by GMIA (2019) and SNI 06-3735-1995, which range from 50 to 300 bloom. Differences in gel strength are mainly due to variations in the content of hydrophobic amino acids and imino acids (proline and hydroxyproline), which are influenced by the amount of collagen and extraction conditions (Abedinia et al., 2020). The higher the gel strength of gelatin, the greater its viscosity. Low viscosity may be caused by the type of tissue in the raw material as well as the conditions of the gelatin extraction process (pH, temperature, time) (Prokopová et al., 2023).

The gelling point is the temperature at which a gelatin solution begins to transition into a gel. The gelling point is influenced by the amount of hydroxyproline amino acid. The gelling point will be lower if the hydroxyproline content in the gelatin raw material is low. The amount of hydroxyproline in gelatin is directly proportional to the number of hydrogen bonds that can form when gelatin is dispersed in water (Zulkifli, Naiu, & Yusuf, 2014). Based on several studies, the gelling point of gelatin from chicken by-products varies between 14 – 28.2°C.

Another important characteristic of gelatin is the melting point. The melting point is the temperature at which gelatin in gel form liquefies when gradually heated. Hydroxyproline content also affects the melting point of gelatin. Gelatin with fewer hydrogen bonds will form a gel at lower temperatures, but the intermolecular bonds of gelatin are weak, causing it to melt quickly. Conversely, a higher number of hydrogen bonds will enable gelatin to form gel more rapidly with stronger intermolecular bonds, thus melting at higher temperatures (Zulkifli et al., 2014). The melting point of gelatin from chicken by-products varies between 23.1 – 69.77°C. The highest melting point was found in chicken feet gelatin in the study by Saenmuang et al. (2020), reaching 69.77±3.89°C.

CONCLUSION

Gelatin produced from chicken processing by-products shows potential as an alternative source of gelatin. The resulting gelatin exhibits varying characteristics in terms of gel strength, gelling point, melting point, and viscosity. Chicken gelatin can cover all categories of gelatin, from low, medium, high, to very high gel strength. This makes it applicable in various industries, particularly in food and pharmaceuticals. Most chicken gelatin in studies conducted over the past 10 years has met the gelatin gel strength standards set by GMIA and SNI. Therefore, gelatin produced from chicken processing by-products offers a promising alternative to meet current gelatin demand while also helping to reduce dependence on imports. However, to ensure its halal status, it is necessary to confirm that the by-products used as raw materials for gelatin originate from halal chicken slaughtering practices.

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