# Poultry as an Alternative Source of Gelatin

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**ABSTRACT:** Global demand for gelatin industry is increasing especially in food and pharmaceutical industry. Major productions of gelatin are from mammalian (porcine and bovine) and the rest are from fish. There are halal issues and health related concerns associated with mammalian gelatin, while for fish gelatin is about allergic reactions. New potential gelatin sources such as poultry skin, feet, and bone has raised to replace mammalian resources. The objective of this review is to present the potentials of gelatin extracted from poultry as an alternative sources of gelatin. Poultry as an alternative doesn't have any dietary concern and can be accepted if it follows the religious requirement. Limited studies on gelatin produced from chicken show that it has higher glycine, hyproxyproline and proline content and exhibited higher thermal stability compared to mammalian and fish gelatin. Poultry gelatin from skin and feet are considered as by-products from poultry, so apart from gelatin extraction, it can minimize the product from poultry waste. This review focuses on current study of gelatin, alternatives sources of gelatin and the challenges of poultry gelatin for future commercial use.

**Keywords**: Food industry, gelatin, imino acid, poultry by-product, poultry feet

## Introduction

Gelatin is the main derivative of collagen (Gilsenan and Ross-Murphy, 2000) that is used primarily in food, pharmaceutical, photographic, and technical products. In food industry, gelatin is utilized in confections (mainly for providing chewiness, texture, and foam stabilization), low fat spreads (to provide stabilization and texturization), bake goods (to provide emulsification, gelling, and stabilization), and meat products (to provide water-binding). While in pharmaceutical industry, gelatin is used to make capsules, tablets, homeostatic sponges, blood plasma substitutes, suppositories, and vitamin encapsulation. For non-food industry, gelatin is used in making film for photography. Thus, the amount of gelatin used in the worldwide industry is increasing (Montero and Gomez-Guillen, 2000).

Gelatin contain high amount of certain amino acid such as glycine, proline and hydroxyproline (Gilsenan and Ross-Murphy, 2000; Arnesen and Gildberg, 2007) but low in cysteine, methionine and tyrosine due to the degradation during hydrolysis (Chapman and Hall, 1997; Jamilah and Harfinder, 2002). Gly-X-Y is the typical sequence of amino acid in gelatin which represents Gly as glycine, X is proline and Y is hydroxyproline. The most abundant amino acid in gelatin is glycine. 25% of dry gelatin contains proline and hydroxyproline which can stabilize its structure (Russell *et al.,* 2007).

The amino acid content of gelatin depends on the raw material used to extract it. Nalinanon *et al*. (2008) reported that percentage of extracted gelatin can be measured by the content of hydroxyproline produced. The differences in molecular weight distribution affected its chemical properties which result from the variation in the nature or extraction conditions (Zhou and Regenstein, 2006). For food grade gelatins, typically it contains 8-12% moisture and less than 2% ash, the remainder being protein which is gelatin (Ledward, 2000).

Porcine and bovine skin gelatins are the main sources of gelatin (Kittiphattanabawon *et al*., 2010) and widely utilized in food manufacturing because the sources are more available. Gelatin from porcine skin gelatin and bovine skin are produced from acidic treatment (Type A) and alkaline treatment (Type B), respectively (Eysturskaro *et al.*, 2009) with isoelectric point of pH 7-9.4 and pH4.8-5.5 (Ledward, 2000).

Jongjareonrak *et al.,* (2006) reported that development of alternative sources for porcine and bovine gelatin has been given priority due to the potential risk of spreading bovine spongiform encephalopathy (BSE), commonly known as mad cow diseases or food and mouth disease (FMD). Besides that, there are religious concerns and halal issues about pork and beef consumption. For example, Islam and Judaism cannot consume any pork related products, while Hindus do not consume beef product (Karim and Bhat, 2009).

**Current Study of Gelatin**

GME (2008) reports the annual world production of gelatin is nearly 326,000 tons, with source from pig skin derived gelatin is the most abundant (46%) output, followed by bovine hides (29.4%), bones (23.1%) and other sources (1.5%). Porcine skin required short time for treatment with acid prior to extraction while for bovine it is subjected to lengthy treatment with alkaline (GMIA, 2012). The raw materials for this mammal are also abundant and the price is lower compared to bovine. A number of studies on developing gelatin alternatives to mammalian gelatin from fish source have been reported including fish skin (Mohtar *et al.,* 2011; Al-Saidi *et al*., 2012) and fish scales (Zhang *et al*., 2011). In South Korea, Jun *et al*. (2000) investigates the feasibility of chicken feet to replace cowhides for jokpyun (traditional Korean gel type food). Gelatin extraction from poultry is mostly come from chicken as shown in **Table 1**. All of those sources are used to maximizing the usage of under-utilised resources and industrial waste.

**Table 1:** Poultry source that had been use in current study

| Source of gelatin | References |
|---|---|
| Chicken feet | Liu *et al*. (2001); Lim *et al*. (2001) |
| Chicken skin | Norizah *et al*. (2013); Cliché *et al.* (2003) |
| Chicken meat residue | Rammaya *et al*. (2012) |
| Silky fowl feet | Cheng *et al*. (2009) |
| Bird feet | Yung and Deng (2006) |

## Alternatives Sources of Gelatin

### *Fish gelatin*

Alternative for porcine and bovine gelatin are fish and poultry. Gelatin of fish which is the marine source has one major advantage as they are not associated with the risk of outbreaks of Bovine Spongiform Encephalopathy. Fish gelatin is acceptable for Islam, and can be used with minimal restrictions in Judaism and Hinduism. Furthermore, fish skin, which is a major by-product of the fish-processing industry, causing waste and pollution, could provide a valuable source of gelatin (Badii and Howell, 2006). Large amount of collagen are from fish skins. Nagai and Suzuki (2000) showed that collagen contents in the fish skin waste of Japanese sea-bass, chub mackerel, and bullhead shark were 51.4%, 49.8%, and 50.1% (dry basis), respectively. Gelatin has been extracted from skins and bones of various warm-water (e.g. tuna, catfish and tilapia) and cold-water (e.g. cod, Alaska pollock and salmon) fish.

Jamilah and Harfinder, (2002) found that, the extraction yield of fish gelatin is lower than mammalian gelatin, giving approximately between 6% and 19% (grams of dry gelatin per 100 g of clean skin). Lower extraction yield of fish gelatin could be due to the loss of extracted collagen through leaching during the series of washing steps or due to incomplete hydrolysis of the collagen. In addition, Intarasirisawat *et al*. (2007) reported that some heat-stable proteases endogenous to the skin are involved in the degradation of gelatin molecules (specifically the *b* and *a* chain) during the extraction process at elevated temperatures, which contribute to lower bloom value.

Imino acids (proline and hydroxyproline) content in fish gelatin also lower compared to mammalian gelatins, but warm-water fish gelatins have a higher imino acid content than cold-water fish geatins (Eastoe and Leach, 1977). Muyonga *et al.* (2004) reported that the proline and hydroxyproline contents are approximately 30% for mammalian gelatins, 22–25% for warm-water fish gelatins (tilapia and Nile perch), and 17% for cold-water fish gelatin (cod).

Fish gelatins have lower gelling and melting temperatures, but relatively higher viscosities compared to mammalian (Leuenberger, 1991). Typical gelling and melting points for fish gelatins range from 8 to 25ºC and 11 to 28ºC, but typical gelling and melting points for porcine and bovine gelatins range are from 20 to 25ºC and 28 to 31ºC.

The origin of the raw material used in gelatin extraction process account for the wide range of gelling temperatures. Besides that, the raw material from fish is failed to pull people's attraction due to the allergic factor. Fish and shellfish are included in the 8 types of food that contribute for more than 90% of allergic reactions (Nieuwenhuizen *et al.*, 2006).

*Poultry Gelatin*

Alternative sources for the production of gelatin have attracted the attention of researcher in the last decades as reviewed by Gomez-Guillen *et al*. (2011). The chicken and duck based poultry can be considered as one of the best income produced poultry since it can provide eggs and meat. It gets good support from the public in Malaysia. From year 2000 to 2010, the production of chicken (123650 to 225790 per head) and duck (31000 to 48200 per head) is increasing (FAOSTAT, 2012). Although the total production of ducks is still less than chickens, duck production increased more rapidly from 766.55 metric tons in 2001 to 1334.47 metric tons in 2011 (Dept. of Veterinary Services Malaysia, 2012).

New gelatin sources such as poultry skin, feet, and bone has increased to replace mammalian resources (Gudmundsson, 2002; Schrieber and Garies, 2007; Karim and Bhat, 2009). Norizah *et al*. (2013) noted that gel strength from chicken gelatin has significantly higher bloom value (355) compared with bovine gelatin (229) due to the intrinstic characteristic such as protein chain composition, molecular weight distribution, amino acid content and types of extraction treatment as well as the properties of collagen. Chicken skin contains approximately 75% type I and 15% type III collagens (Abedin and Riemschneider, 1984). Chicken skin is chiefly made into animal meal, whereas a smaller proportion is incorporated into meat emulsions or used as a source of fat mainly for soup preparation (Cliché *et al*., 2003). Schrieber and Garies, 2007 reported that poultry skins contain a lot of fat and the concentration of collagen is low, thus preferable to use other material such as feet.

Poultry feet (duck and chicken) are another potential source of gelatin production from waste product of poultry. The huge chicken and duck production in Malaysia means that a great deal of by-products (feets) is also produced, and provide readily available source of raw material to produce poultry feet gelatin. Limited studies on gelatins produced from broiler chicken feet have been reported. For example, Lin and Liu (2006) reported that collagen extracted from chicken broiler feet had higher hyproxyproline (Hyp) and proline (Pro) content and exhibited higher thermal stability.

**Table 2** showed the amino acid content for chicken gelatin compared with porcine, bovine and fish gelatin. Chicken skin gelatin showed similar properties with other gelatin and it contains high value of certain amino acid. Chicken skin gelatin has the highest imino acid, this composition is important for gelling effect (Gómez-Guillén *et al.,* 2011) and it play an important role in gel strength (Wangtueai and Noomhorm, 2009). From the table, it is similar with previous studies on amino acids content of collagen. It was reported that aquatic animal collagen such as fish collagen contains lower imino acids compared to mammal's collagen (Montero and Gomez-Guillen 2000; Lin and Liu, 2006).

**Table 2:** Amino acid content in chicken gelatin compared to porcine, bovine and fish gelatine

| Amino acid (%) | | [a]Chicken skin | [b]Porcine skin | [c]Bovine skin | [d]Fish skin | |
|---|---|---|---|---|---|---|
| Alanine | Ala | 101 | 112 | 113 | 123 | [a]Norizah *et al.* (2013) |
| Arginine | Arg | 56 | 49 | 47 | 47 | |
| Aspartic acid | Asp | 21 | 46 | 46 | 48 | [b]Eastoe and Leach, (1997) |
| Cystine | Cys | 1.6 | 0 | 0 | 0 | |
| Glycine | Gly | 337 | 330 | 342 | 347 | [c]Gomez-Estaca *et al*. (2009) |
| Glutamic acid | Glu | 58 | 72 | 74 | 69 | |
| Histidine | His | 30 | 4 | 4 | 6 | [d]Sarabia *et al*. (2000) |
| Hydroxyproline | Hyp | 121 | 91 | 83 | 79 | |
| Isoleucine | Ile | 12 | 10 | 11 | 8 | |
| Leucine | Leu | 26 | 24 | 24 | 23 | |
| Lysine | Lys | 47 | 27 | 25 | 25 | |
| Methionine | Met | 7 | 4 | 4 | 9 | |
| Phenylalanine | Phe | 18 | 14 | 12 | 13 | |
| Proline | Pro | 134 | 132 | 127 | 119 | |
| Serine | Ser | 22 | 35 | 39 | 35 | |
| Threonine | Thr | 10 | 18 | 33 | 24 | |
| Tyrosine | Tyr | 12 | 3 | 4 | 2 | |
| Valine | Val | 19 | 26 | 19 | 15 | |
| Imino acid | (Hyp+Pro) | 255 | 223 | 215 | 198 | |

Cheng *et al*. (2009) noted that silky fowl feet is a useful industrial by-product, as the collagen extraction yield is 7.3% and collagen content is 516.6 mg/g. Cheng *et al.* (2009) also noted that collagen extracted using the acetic acid-pepsin solubilization method showed the highest yield and collagen content among the methods tested. Cliché *et al*. (2003) showed that, yields obtained in 100kg of chicken skin could generate between 860g of collagen with telopeptides and 950g without telopeptides. Norizah *et al*. (2013) noted that, the yield of chicken skin gelatin is 16 % based on dry weight basis. Thus, poultry can be a potential alternative gelatin source.

## Challenges of Poultry Gelatin for Future Commercial Use

Compared to bovine, porcine and fish gelatin, the market share of poultry gelatin is still considered very small. Limiting factors with poultry gelatin industry included:

- Availability of raw materials: The production of poultry which is chicken and duck in Malaysia for year 2010 is 225790 and 48200 respectively; it is lower than the production of cattle and pig which is 909810 and 1710950 respectively (FAOSTAT, 2012). Poultry production is still considered very low compared to mammalian, so the production of poultry gelatin is limited. Besides that, the production of consistent poultry species in adequate quantities is difficult for gelatin manufacture. Another factor is the difficulty to obtain certification on poultry raw material. Certification is for the traceability, which is the essential requirement for food additives especially from animal source (Karim and Bhat, 2009).
- Price: Price of poultry especially ducks meat is usually higher and it often discourages people from buying it more often (Mead, 2004). Production of gelatin especially from duck will be high price in market because of limited source of raw material.
- Quality of gelatin: Poultry skin, feet and bone is used for gelatin extraction, so variable quality of gelatin will be produce because of the different composition of raw material from poultry waste by product. Other than that, extraction using different species, origin and extraction process also can influence the quality of gelatin.
- Health concern: Although there is no dietary concern, but there are health concerns regarding avian influenza virus or bird flu. There are several types of bird flu and the most common bird flu is H5N1. H5N1 was the first avian influenza virus to infect humans. The first infection occurred in Hong Kong in 1997 (PubMed Health, 2011).

## Conclusion

Poultry as an alternative source of gelatin shows similar chemical composition in imino acid content of bovine, porcine and fish gelatin. Although the total production of poultry gelatin may not significantly increase for this time being, but at least in the future, it might be able to replace the gelatin from conventional sources. In order to meet the global demand, hopefully gelatin from poultry could potentially be an alternative to commercial gelatin and might become a new product that offering unique and competitive properties to other biopolymers.

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## References

Abedin, M. Z. and Riemschneider, R. (1984). Chicken skin collagen- molecular diversity and susceptibility to neutral proteinases. *Pharmaceutical Industry*, **46**:532–535.

Al-Saidi, G.S., Al-Alawi, A., Rahman, M.S. and Guizani, N. (2012). Fourier transform infrared (FTIR) spectroscopic study of extracted gelatin from shaari (Lithrinus microdon) skin: effects of extraction conditions. *International Food Research Journal*, **19(3)**: 1167-1173.

Arnesen, J. A. and Gildberg, A. (2007). Extraction and Characterization of Gelatin from Atlantic Salmon (Salmo solar) Skin. *Bioresource Technology*, **98**: 53-57.

Badii, F. and Howell, N. K. (2006). Fish gelatin: structure, gelling properties and interaction with egg albumen proteins. *Food Hydrocolloids*, **20(5)**: 630-640.

Chapman and Hall. (1997). Thickening and gelling agents for food. 2nd edition, Blackie Academic and Professional, London, 150-153.

Cheng, F.Y., Hsu, F.W., Chang, H.S., Lin, L.C. and Sakata, R. (2009). Effect of different acids on the extraction of pepsin-solubilised collagen containing melanin from silky fowl feet. *Food Chemistry*, **113**: 563–567.

Cliché, S., Amiot, J., Avezard, C. and Gariepy, C. (2003). Extraction and characterization of collagen with or without telopeptides from chicken skin. *International Journal of Poultry Science*, **82**: 503-509.

Dept. of Veterinary Services Malaysia. (2012). Livestock statistic [Internet]. Malaysia: Dept. of Veterinary Services Malaysia. http://www.dvs.gov.my. Accessed on 10 September 2012.

Eastoe, J.E. and Leach, A.A. (1977). Chemical constitution of gelatin. In A.G. Ward and A. Courts (Eds). The Science and Technology of Gelatin Academic Press, London, 73-107.

Eysturskaro, J., Haug, I.J., Ulset, A. and Draget, K.I. (2009). Mechanical properties of mammalian and fish gelatins based on their weight average molecular weight and molecular weight distribution. *Food Hydrocolloids*, **23(8)**: 2315–2321.

Food and Agriculture Organization of the United Nations (FAOSTAT). (2012). http://faostat3.fao.org/home/index.html#VISUALIZE_BY_DOMAIN. Accessed on 19 October 2012.

Gilsenan, P. M. and Ross-Murphy, S. B. (2000). Rheological Characterisation of Gelatins from Mammalian and Marine Sources. *Food Hydrocolloid*, **14**: 191-195

Gelatine Manufactures of Europe (GME). (2008). All about gelatin. Gelatine Manufactures of Europe, Europe. http://www.gelatine.org/en.html.

Gelatin Manufacture Institute of America (GMIA). (2012). Gelatin handbook. http: //www.gelatin-gmia.com/images/GMIA_Gelatin_Manual_2012. Accessed on 24 October 2012.

Gomez-Estaca, J., Montero, P., Fernandez-Martin, F. and Gomez-Guillen, M.C. (2009). Physico-chemical and film-forming properties of bovine hide and tuna skin gelatin: A comparative study. *Journal of Food Engineering*, **90**: 480-486.

Gomez-Guillen, M. C., Gimenez, B., Lopez-Caballero, M. E. and Montero, M. P. (2011). Functional and bioactive properties of collagen and gelatine from alternative sources: A review. *Food Hydrocolloids*, **25**: 1813-1827.

Gudmundsson, M.(2002). Rheological properties of fish gelatins. *Journal of Food Science*, **67**: 2172–2176.

Intarasirisawat, R., Benjakul, S., Visessanguan, W., Prodpran, T., Tanaka, M. and Howell, N. K. (2007). Autolysis study of bigeye snapper (Priacanthus macracanthus) skin and its effect on gelatin. *Food Hydrocolloid*, **21**: 537-544.

Jamilah, B. and Harfinder, K.G. (2002). Properties of gelatins from skins of fish black tipalia (Oreochromis mossambicus) and red tilapia (Oreochromis nilotica). *Food Chemistry*, **77**:81-84.

Jongjareonrak, A., Benjakul, S., Visessanguan, W. and Tanaka, M. (2006). Effects of plasticizers on the properties of edible films from skin gelatin of bigeye snapper and brownstripe red snapper. *European Food Research and Technology*, **222**: 229–230.

Jun, M., Lee, K.S. and Kim, K.O. (2000). The effect of preparation conditions on the properties of Jokpyun (traditional Korean gel type food) model system. *Food Science and Biotechnology*, **9(27)**: 27-31.

Karim, A.A. and Bhat, R. (2009). Fish gelatin: properties, challenges, and prospects as an alternative to mammalian gelatins. *Food Hydrocolloids*, **23**:563-576.

Kittiphattanabawon, P., Benjakul, S., Visessanguan, W. and Shahidi, F. (2010). Comparative study on characteristics of gelatin from the skins of brownbanded bamboo shark and blacktip shark as affected by extraction conditions. *Food Hydrocolloids*, **24**: 164-171.

Ledward, D.A. (2000). Gelatin. In G.O. Phillips and P.A. Williams (eds). Handbook of hydrocolloids. *Boca Raton: CRC Press*, 67-86.

Leuenberger, B.H. (1991). Investigation of viscosity and gelation properties of different mammalian and fish gelatins. *Food Hydrocolloids*, **5**: 353-361.

Lim, J., Oh, S. and Kim, K.O. (2001). The effects of processing conditions on the properties of chicken feet gelatin. *Food Science and Biotechnology*, **10(6)**: 638-645.

Lin, Y.K. and Liu, D.C. (2006). Effects of pepsin digestion at different temperatures and times on properties of telopeptide-poor collagen from bird feet. *Food Chemistry*, **94**: 621–625.

Liu, D.C., Lin Y.K. and Chen M.T. (2001). Optimum condition of exracting collagen from chicken feet and its characteristics. *Asian-Australasian Journal of Animal Sciences*, **14(11)**: 1638-1644.

Mead, G.C. (2004). Poultry meat processing and quali*ty*. Woodhead Publishing in Food Science and Technology. *CRC Press, USA*, 228-330

Mohtar, N.F., Perera, C.O. and Quek,S.Y. (2011). Utilisation of gelatine from NZ hoki (Macruronus novaezelandiae) fish skins. *International Food Research Journal*, **18(3)**: 1111-1115.

Montero, M. P. and Gomez-Guillen, M. C. (2000). Extracting conditions for megrim (Lepidorhombus boscii) skin collagen affect functional properties of the resulting gelatin. *Journal of Food Science*, **65**:434–438.

Muyonga, J.H, Cole, C.G.B. and Duoku, K.G. (2004). Extraction and physicochemical characterisation of Nile perch (Lates niloticus) skin and bone gelatin. *Food Hydrocolloids*, **18**: 581-592.

Nagai, T. and Suzuki, N. (2000). Isolation of collagen from fish waste material skin, bone and fins. *Food Chemistry*, **68**: 277-281.

Nalinanon, S., Benjakul, S., Visessanguan, W. and Kishimura, H. (2008). Improvement of gelatin extraction from bigeye snapper skin using pepsinaided process in combination with protease inhibitor. *Food Hydrocolloids,* 22(4): 615-622.

Nieuwenhuizen, N., Lopata, A.L., Jeebhay M.F., Herbert D.R., Robins T.G. and Brombacher, F. (2006). Exposure to the fish parasite Anisakis causes allergic airway hyperreactivity and dermatitis. *Journal of Allergy and Clinical Immunology*, **117(5)**: 1098-1105.

Norizah, M.S., Badii, F. and Howell, N.K. (2013). Preparation and characterisation of chicken skin gelatin as an alternative to mammalian gelatin. *Food Hydrocolloids,* **30**: 143-151.

PubMed Health. (2011). *Avian influenza*. http :// www. ncbi. nlm. nih.gov/pubmedhealth/PMH0004522/.Accessed on 03 December 2012

Rammaya, K., Voon, Q. Y. and Babji, A.S. (2012). Physicochemical analysis of gelatin extracted from mechanically deboned chicken meat residue. *International Journal of Food, Nutrition and Public Health*, **5(1/2/3)**: 147-168.

Russell, J. D., Dolphin, J. M. and Koppang, M. D. (2007). Selective analysis of secondary amino acids in gelatin using pulsed electrochemical detection. *Analytical Chemistry*, **79**: 6615-6621.

Sarabia, A.I., Gomez-Guillen, M.C. and Montero, P. (2000). The effect of added salts on the viscoelastic properties of fish skin gelatin. *Food Chemistry,* **70**:71-76.

Schrieber, R. and Gareis, H. (2007). Gelatine handbook. Weinhem: Wiley-VCH GmbH & Co.

Wangtueai, S. and Noomhorm, A. (2009). Processing optimization and characterization of gelatin from lizardfish (Saurida spp.) scales. *LWT - Food Science and Technology*, **42**: 825–834

Yung, K.L. and Deng, C.L. (2006). Effects of pepsin digestion at different temperatures and times on properties of telopeptide-poor collagen from bird feet. *Food Chemistry*, **94**: 621-625.

Zhang, F., Xu, S. and Wang, Z. (2011). Pre-treatment optimization and properties of gelatin drom freshwater fish scales. *Food and Bioproducts Processing*, **89**: 185-193.

Zhou, P. and Regenstein, J.M. (2006). Determination of total protein content in gelatin solutions with the Lowry or Biuret Assay. *Journal of Food Science,* **71(8)**: 474-479.