Amino acid and proximate composition of fish bone gelatin from different warm-water species: A comparative study

Y Atma

Department of Food Science and Technology, Universitas Trilogi. Jln. Taman Makam Pahlawan Kalibata No.1, South Jakarta 12760, Indonesia

Email: yoniatma@trilogi.ac.id

Abstract. Research on fish bone gelatin has been increased in the last decade. The quality of gelatin depends on its physicochemical properties. Fish bone gelatin from warm-water fishes has a superior amino acid composition than cold-water fishes. The composition of amino acid can determine the strength and stability of gelatin. Thus, it is important to analyze the composition of amino acid as well as proximate composition for potential gelatin material. The warm water fish species used in this study were Grass carp, Pangasius catfish, Catfish, Lizard fish, Tiger-toothed croaker, Pink perch, Red snapper, Brown spotted grouper, and King weakfish. There were five dominant amino acid in fish bone gelatin including glycine (21.2-36.7%), proline (8.7-11.7%), hydroxyproline (5.3-9.6%), alanine (8.48-12.9%), and glutamic acid (7.23-10.15%). Different warm-water species has some differences in amino acid composition. The proximate composition showed that fishbone gelatin from Pangasius catfish has the highest protein content. The water composition of all fishbone gelatin was well suited to the standard. Meanwhile, based on ash content, only gelatin from gelatin Pangasius catfish met the standard for food industries.

1. Introduction

Gelatin has been widely used in food, pharmaceutical and cosmetic industries. Gelatin is mainly used to improve the gelation, water binding, foaming, emulsifying, elasticity and viscosity of food products. Furthermore, gelatin is applicable for encapsulation and edible film formation purposes, making it interesting for the biomaterial-based packaging, as well as photographic industries [1]. Nevertheless, commercial gelatin from the mammals such as pig skins, cattle hides, and cattle bones are unacceptable by some religions like as Judaism, Hinduism, and Islam. Therefore, the seeking of an alternative source of gelatin has been increasing in the last decade. The waste from the fish processing is potential source of gelatin. More than 30% fish weight comes from skin and bones [2]. The skins sometimes are still used in the further processing, but the bones are often discarded. Thus, utilization of fish bone as a source of gelatin can minimize waste as well as add value for this particular fishery products.

The indicator of fish bone gelatin production can be analysed both qualitatively and quantitatively. The quality of gelatin is mostly determined by physicochemical properties. It is expected to have the same quality as well as the commercial gelatin. The physicochemical characteristics of fish bone gelatin are gel strength, stability, visco-elasticity, amino acid and proximate composition. In the previous study, it is stated that fish bone gelatin from warm-water fishes has a superior amino acid
than that cold-water fishes. It gives effect to the stability and gel strength of fishbone gelatin [3].

Moreover, Gomez-Guillen et al. stated that fish bone gelatin from warm-water fish has better thermostability and rheology than cold-water fish [4]. Wang and Regenstein stated that there are positive correlations between composition of amino acid hydroxyproline (Hyp) and gel strength [5]. High content of amino acids (Hyp+Proline) have been improve the rheological (viscoelasticity and gel strength) and stability of fish gelatin meanwhile glycine is important for gel strength [6]. The chemical quality of gelatin can also be indicated by proximate composition.

Protein is the most abundant compound in collagenous material, thus, it represents the maximum yield of gelatin extraction [7]. In addition to protein content, ash and water in collagenous material contribute to the quality of gelatin, as the maximum level of ash and water for food application are 2.6% [8] and 15% [9], respectively. About 6-8% of water content leads to the hygroscopic gelatious material. Meanwhile, 13% of water content leads to the reduction size of particle, since the glass transition temperature of gelatin is about 64 °C [10].

The objective of this study was to compare the amino acids and proximate compositions of fish bone gelatin from warm-water fish species. This study may give additional information regarding the correlation between amino acids and proximate composition toward physicochemistry properties of fishbone gelatin which can be used for further studies.

2. Research workflow and result

Three consecutive research steps were conducted for this study: (1) selection of related research publications, (2) clusterization upon warm-water fish species and (3) comparison analysis of both amino acid and proximate compositions (figure 1). The clusterization was important to specify the warm water fish species used in this study, since numerous fish species has been used for the production of gelatin. Warm water fish species were choosen and clarified based on the data available on fishbase.org

```
Fishbone gelatin research and publication
  ▼
Name of species
  ▼
  Fishbase.org
  ▼
Selected warm-water species
  ▼
Amino acid and proximate comparation
```

Figure 1. Research workflow.

2.1. Warm-water fish

The warm-water species were used in this study were Grass carp (Ctenopharyngodon idella), Pangasius catfish (Pangasius sutchi) [8], Catfish (Clarias gariepinus) [6], Lizard fish (Saurida spp.) [11], Tiger-toothed croaker (Otolithes ruber) and Pink perch (Nemipterus japonicus), Red snapper (Lutjanus campechanus), Brown spotted grouper (Epinephelus chlorostigma), and King weakfish (Macrodon ancylophon) [10,12,13].
2.2. Amino acid composition

There are five dominant amino acids in fish bone gelatin including glycine (21.2-36.7%), proline (8.7-11.7%), hydroxyproline (5.3-9.6%), alanine (8.48-12.9%), and glutamic acid (7.23-10.15%) (table 1).

Table 1. Amino acid composition of fishbone gelatin form warm-water fish.

| Amino acid (%) /Species | Code | Grass carp[5] | Pangasius catfish[1] | Catfish[2] | Lizard fish[7] | King Weakfish[6] | Comercial Gelatin[1] |
|------------------------|------|---------------|---------------------|------------|---------------|------------------|---------------------|
| Alanin                 | Ala  | 12.9          | 8.48                | 9.1        | 9.1           | 9.75             | 7.73                |
| Arginin                | Arg  | 5             | 8.11                | 6          | 5.36          | 7.25             | 7.01                |
| Aspartic acid          | Asp  | 4.7           | 4.62                | 6.5        | 5.36          | 0                | 4.97                |
| Asparagin              | Asn  | 0             | 0                   | 0          | 0             | 5.35             | 0                   |
| Cysteine               | Cys  | 0             | 0                   | 0          | 0             | 0                | 0                   |
| Glutamic acid          | Glu  | 7.7           | 8.16                | 9.1        | 7.23          | 10.15            | 6.19                |
| Glycine                | Gly  | 36.7          | 25.02               | 21.2       | 30.34         | 24.42            | 42.71               |
| Histidine              | His  | 0.5           | 0.8                 | -          | 0.9           | 0.92             | 1.02                |
| Hydroxyproline         | Hyp  | 7             | 5.97                | 5.3        | 8.13          | 9.6              | 6.49                |
| Isoleucine             | Ile  | 1             | 1.33                | 1.5        | 0.85          | 1.73             | 1.35                |
| Leucine                | Leu  | 2.1           | 2.23                | 2.5        | 1.9           | 2.54             | 2.42                |
| Lysine                 | Lys  | 2.5           | 3.13                | 3.5        | 2.1           | 3.25             | 3.11                |
| Methionine             | Met  | 1.3           | 10.83               | 7.7        | 1.35          | 1.85             | 6.43                |
| Phenylalanin           | Phe  | 1.3           | 1.7                 | 2.9        | 1.4           | 1.9              | 1.63                |
| Proline                | Pro  | 8.7           | 11.4                | 9          | 11.7          | 10.25            | 11.09               |
| Serine                 | Ser  | 3.9           | 3.08                | 3.8        | 3.4           | 3.25             | 2.87                |
| Threonine              | Thr  | 2.5           | 2.45                | 3.9        | 1.53          | 2.82             | 1.43                |
| Tyrosine               | Tyr  | 0.4           | 0.53                | 0.6        | 0.3           | 0.75             | 0.4                 |
| Valine                 | Val  | 1.8           | 2.19                | 2.5        | 1.84          | 1.6              | 2.08                |
| Hydroxylisin           | Hyl  | 0             | 0                   | 0          | 0             | 0.85             | 0                   |
| Total                  |      | 100           | 100                 | 100        | 100           | 100              | 100                 |
| Hydroxyproline         |      | 15.7          | 17.37               | 14.3       | 19.83         | 19.85            | 17.58               |

2.3. Proximate composition

Table 2. Proximate composition (%) of fishbone gelatin from warm-water fish and commercial gelatin.

| Proximate properties (%) /species | Pangasius catfish[1] | Catfish[2] | Lizard fish[3] | Tiger-toothed croaker[3] | Pink perch[4] | Red snapper[4] | Brown spotted grouper[4] | King Weakfish[6] | Comercial Gelatin[1] |
|----------------------------------|----------------------|------------|----------------|------------------------|--------------|--------------|------------------------|------------------|---------------------|
| Water                            | 9.2                  | 11.43      | 8.27           | 10.33                  | 8.56         | 6.24         | 4.1                    | 9.9              | < 15                |
| Protein                          | 87.3                 | 81.75      | 81.89          | 82.5                   | 69.49        | 78.56        | 82.36                  | 82.3             | 86.1*               |
| Ash                              | 2.6                  | 5.6        | 11.17          | 2.7                    | 2.8          | 10.32        | 6.58                   | 3.8              | < 2.6               |
| Lipid                            | 0.96                 | 0.95       | 0.01           | 0.52                   | 0.32         | 5.16         | 3.92                   | -                | -                   |

*) Bovine gelatin [14]

3. Discussion

From this study, it is likely that amino acid compositions varied in each warm-water species. Importantly, we noticed that Glycine (Gly) was the highest content of amino acid in most of the fishbone gelatin. Methionine was relatively high in fishbone gelatin of Pangasius catfish and Catfish, but it was found in low concentration in Grass carp, Lizard fish and King Weakfish. Histidine was
occurred in low level in most of the fish species and almost un-detectable in catfish. Interestingly, Hydroxyproline of Tiger toothed croaker was occurred within 7.51% and Pink perch 7.41%.

Based on the proximate compositions, fishbone gelatin from Pangasius catfish has the highest protein content (table 2). The protein content, however, is not quite necessary for new gelatin discoveries, since gelatin itself is considered as highly-abundant protein material. On the other hand, high protein would be important for an optimum extraction step [15]. The water composition in all fish bone gelatin from warm-water fish suited to the standard. Judging from water content alone, the gelatin from Red snapper and Brown spotted-grouper were considered as hygroscopic gelatin. Based on ash content, amongst the warm water fish tested, only gelatin from Pangasius catfish met the standard of that commercial gelatin for food application.

Based on our study, King weakfish and Lizard fish have the highest hydroxyproline and amino acid compositions among others, contrarily to their corresponding gel strength value (figure 2). Thus, previous reports regarding the correlation between the content of amino acids, particularly, hydroxyproline with gel can not be fully accepted. However, it has been reported the gel strength value can be influenced by the composition of several amino acids, extraction method and molecular weight distribution [6, 16, 17].

![Source of fishbone gelatin](image)

**Figure 2.** Hydroxyproline and amino acid composition (%) and gel strength (g) of fishbone gelatin from warm-water species.

**References**

1. Karayannakidis P D and Zotos A 2014 *J Aquat Food Prod T* **25** 1
2. Shyni K, Hema G S, Ninan G, Mathew S, Joshy C G, Lakshmanan P T 2014 *Food Hydrocolloid* **39** 68-76
3. Zhang F, Xu S and Wang Z 2011 *Food Bioprod process* **89** 185–93
4. Gomez-Guillen M C, Perez-Mateos M, Gomez-Estaca J, Lopez-Caballero E, Gimenez B and Montero P 2009 *Trends Food Sci Tech* **20** 3-16
5. Wang Y and Regestein 2009 *Food Chem* **74** 426-31
6. Sanaei A V, Mahmoodani F, See S F, Yusop S M and Babji A S 2013 *Int Food Res J.* **20** 1
7. Muyoga J H, Cole C G B and Duodu K G 2004 *Food Chem* **85** 81-9
8. Mahmoodani F, Sanaei A V, See SF, Yusop S M, and Babji A S 2014 *J Food Sci Technol* **51** 11
9. GME 2005 Standard Methods for the Testing of Edible Gelatine, Gelatine Monograph, Gelatin Manufacturers of Europe
[10] Koli J M, Basua S, Nayaka B B, Patageb S B, Pagarkarb A U and Gudipatia V 2012 Food Bioprod Process 90 555-62
[11] Taheri A, Kenari A A, Gildberg A and Behnam S 2009 J. Food Sci 74 160-65
[12] Shakila R J, Jeevithan E, Vratharajakumar A, Jeyasekaran G and Sukumar D 2012 Food Sci Technol 48 30-6
[13] Alfaro A T, Costa C S, Fonseca G G and Prentice C 2009 Food Sci Tech Int. 15 6
[14] Chuaynukul K, Prodpran T and Benjakul S 2014 Res J Chem Environ 2 4
[15] Sanei V A, Mahmoodani F, See S F, Yusop S M and Babji AS 2013 Sains Malays 42 12
[16] Nurul A G and Sarbon N M 2015 Int Food Res J 22 2
[17] Raja Mohd Hafidz R N, Yaakob C M, Amin I and Noorfaizan A 2011 Int Food Res J 18 813-17