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Fish Bone and Scale as a Potential Source of Halal Gelatin

[1,2]Herpandi, [1]N. Huda and [1]F. Adzitey

[1]Laboratory of Fish and Meat Processing, Food Technology Programme, School of Industrial Technology, Universiti Sains Malaysia, Minden, 11800 Penang, Malaysia

[2]Department of Fish Product Technology, Sriwijaya University, South Sumatera, Indonesia

Corresponding Author: Nurul Huda, Leboratory of Fish and Meat Processing, Food Technology Programme, School of Industrial Technology, Universiti Sains Malaysia, Minden 11800, Malaysia Tel: +604-6532112 Fax: +604-6573678

ABSTRACT

Fish gelatin is an important alternative gelatin which can be considered as Halal and acceptable by all religions. It is made from fish by-products of which fish skin is the most widely used part. The collagen and gelatin-like property of fish bones and scales coupled with their readily availability make it a potential source for development into gelatin products. This review discusses the potentials for the development and utilization of fish bones and scales in the production of gelatins. It also looks at the raw materials, processes, properties and the improvement of fish gelatins for future commercial use.

Key words: Gelatin, fish, bones, scales, extraction

INTRODUCTION

Gelatin is a popular collagen derivative primarily used in food, pharmaceutical, photographic and technical products. In foods, gelatin provides a melts-in-the-mouth function and to achieve a thermo-reversible gel property. Its clarity, bland flavor, emulsifying characteristics, stability, texture properties and the ability to be applied in a wide range of pH, makes it suitable to be used in confectionaries and dairy products (GMIA, 2001). In addition, it is recommended for used as a dietetic food, salt reducer, flocculating agent, protein enrichment and adhesives. In the pharmaceutical industry gelatin is generally used in capsules, tablets, haemostatic sponge, blood plasma substitutes, suppositories and vitamin encapsulation (GME, 2010).

Gelatin is obtained from the degradation of collagen, thus collagen-containing tissues are generally used as sources of gelatin. In mammals, birds and fishes, the most commonly used source of collagen for gelatin is obtained from body protein constituents of the skin, tendons, cartilage, bone and connective tissue, whereas in invertebrates, collagen is an essential constituent of the body wall (Balian and Bowes, 1977). Porcine and bovine gelatins are still the most widely used today; therefore the development of alternative sources of gelatin is one of the issues that have been given much priority. In addition to the health related issues that, bovine gelatin has a potential risk of spreading bovine spongiform encephalopathy (BSE), widely known as mad cow diseases and foot-and-mouth disease (FMD) (Jongjareonrak *et al*., 2005), it used is vitally limited by religious concerns. For instance, Hindus do not consume cow-related product (Karim and Bhat, 2009). Similarly, Islam considers all pork-related products to be non Halal and prohibited to be consumed. Thus researches into the used of some alternative source of gelatins are

being pursued. Such researches include the exploitation of marine and poultry products. It has been established that fish and fish products in generally can be considered as Halal food as long as it does not contain toxins and poisons (Huda *et al*., 1999). Therefore, the objective of this review is to present the potentials of using fish bones and scales for gelatins and available technologies to improve upon the yield of fish gelatins.

RAW MATERIAL OF HALAL GELATIN

Gelatin is a product of rapidly growing market. In 2003, the world market for gelatin reached 278.300 tons; consisting of 42.4% from pig-skin origin, 29.3% bovine hides, 27.6% bones and 0.7% from other sources (GEA, 2010). In previous years, (Karim and Bhat, 2009) reported that the annual world output of gelatin increased to 326.000 tons with the highest source being pig-skin (46%), followed by bovine hides (29.4%), bones (23.1%) and other sources (1.5%). In such proportions, existing gelatins do not meet the demands of the Halal market. As such alternative sources of collagen for gelatin from other sources other than porcine and bovine have been studied. They include previous studies on fish skin, bone and fins collagen isolation by (Nagai and Suzuki, 2000), sea urchin by Robinson (1997), jellyfish by Nagai *et al*. (2000) and bird feet by Lin and Liu (2006).

The production of gelatin from fish waste is a topic that has gain much attention, especially from fish skin due to its properties and qualities. In addition to the nature of the fish, that is almost acceptable by all communities, it also provides a solution to the utilization of huge amounts of fish wastes produced by the fish industry. For instance Guerard *et al*. (2001) reported that, canned fish processing generates solid wastes composed of muscles after the loins have been taken, fish viscera, gills, flesh dark/dark muscle, head, bone, and skin, which can be as high as 70% of the original material. Whereas skin, scale and bone wastes consist of more than 30% of fish processing (Kittiphattanabawon *et al*., 2005). As the total world fisheries reaches about 141.6 million tons (FAO, 2006), with anticipated increases in subsequent years, it's a worth taken effort to utilize the large quantities of fish waste into useful products such as fish gelatin.

PROCESSING OF GELATIN

Fish skin, the common source of Halal gelatin: Gelatin can be obtained in several ways. Johns and Courts (1977) demonstrated that, the breakage of cross-links and non-covalent bonds of collagen can be done by direct thermal treatment, use of acidic or alkaline and enzymatic pre-treatments. Acidic and alkaline pre-treatment is the most widely used method, and has advantage over the direct thermal pre-treatment that is carried out under high temperature (heating and autoclaving), which produces an gel inferior quality.

In recent times, fish skin is the most widely used fish raw material for making fish gelatin. In previous works, gelatin extraction from fish species have been carried out using Alaskan pollock skin (Zhou and Regenstein, 2004, 2005), yellow-fin tuna (Cho *et al*., 2005), Atlantic cod (Arnesen and Gildberg, 2006), bigeye and brownstripe red Snapper (Jongjareonrak *et al*., 2005), Channel catfish skin (Liu *et al*., 2008), shark cartilage (Cho *et al*., 2004), grass carp skin (Kasankala *et al*., 2007), Nile perch skin and bone (Muyonga *et al*., 2004), and many more.

Gelatin from acid-treated collagen, known as type A gelatin is the most widely reported type of gelatin derived from fish skin material. Karim and Bhat (2009) confirmed that acidic treatment is most suitable method to be applied for fish skin due to its less covalently cross-linked collagen. Apart from acidic pre-treatment for Nile perch skin and alkaline pre-treatment for big eye snapper as

reported by Muyonga *et al.* (2004) and Benjakul *et al.* (2009), respectively. Pre-treatment can be done simultaneously using both acidic and alkaline treatment as showen by Zhou and Regenstein (2005). Zhou and Regenstein (2005) found that alkaline and acidic pre-treatments had positive effect on removing non-collagenous proteins and resulted in high gelatin yield and gel strength in Alaska Pollock gelatin. Furthermore, they also mentioned that alkaline treatment followed by acid neutralization provide a neutral or weak acid extraction medium that makes it possible to produce high gelatin yield.

The removal of non-collagenous materials has been a common preparatory step in collagen isolation and the extraction of gelatin. Nagai and Suzuki (2000) performed the removal of non-collagenous proteins with 0.1 N NaOH under 4°C. In fish skin gelatin production, this step is continued to swelling step using low concentration of either acid or alkali solution. Previous research carried out by Huda *et al.* (2004) indicated that, different concentrations of acetic acid (1, 2, 3 and 4%) during pre-treatment had no significant effect on sensory evaluation of the produced gelatin. Contrarily, Yang *et al.* (2007) mentioned that acid solution concentration had significant effect on yield of protein and viscosity of gelatin in their work involving channel catfish.

After pre-treatment process, the gelatin can be extracted with aqueous extraction and heating (by gentle and mild temperatures) treatment. The extraction can be performed at a temperature between 50-90°C for 1-6 h before it is separated, evaporated and usually freeze dried (Wangtueai and Noomhornm, 2009; Zhang *et al.*, 2010). This step distinguishes between gelatin extractions processes and the isolation of collagen. In collagen isolation process, collagen is not denatured by heating, but is extracted using the acid repeatedly and then separated, most commonly by using salting process.

Several fish skin-based gelatin has been reported to have varied bloom value (gel strength) compared with food grade bovine origin. Benjakul *et al.* (2009) reported that gelatin derived from two species of bigeye snapper fish has bloom strength value of 227.73 and 254.10, which was lower when compared to gelatin from bovine bones (293.22). Furthermore Gomez-Guillen *et al.* (2002) found a bloom value of 350 and 340, for sole and megrim fish species, respectively. Although bloom values between fish skin gelatins and other gelatin sources vary, fewer works done on fish skin for producing gelatin reveals that fish skin is one of potential source of high quality gelatin. Fish bone and fish scale could also be a potential source of gelatin due to its similar collagen characteristic to fish skins as reported by Wang *et al.* (2008), who showed that collagen composition as isolated from the skin, scale and bone of deep sea redfish had similar amino acid profile.

Isolation of gelatin from fish bones and scales: There are slight differences in the process of isolating gelatin from fish skins, bones and scales due to differences in their characteristics. For bones and scales, demineralized (decalcified) treatment is a common process employed after removal of non-collagenous material prior to the acid solution treatment. This process can be carried out by immersion using compounds such as EDTA until the hard part of bones disappears. In carp samples, skipjack tuna, Japanese sea bass, ayu, yellow sea bream, chub mackerel, and bullhead shark, demineralization takes 5 days (Nagai and Suzuki, 2000a; Duan *et al.*, 2009). Demineralization has also been achieved using 3% HCl at ambient temperature in Nile perch bones in approximately 9-12 days until a leached bone (ossein) is formed (Muyonga *et al.*, 2004). This demineralization period is much longer when compared to acid treatments on skin samples of the same species which only took 16 h. Furthermore, Wangtueai and Noomhornm (2009) employed

a low alkaline concentration(0.1-0.9%) at 30°C for 1-5 h to process lizardfish scales, whereas Arafah *et al.* (2008) used 4-6% HCl in 24-48 h demineralization period for snakehead fish bone. In addition to the demineralization process, raw materials from both porcine and bovine bones undergo a process of defatting (GEA, 2010). In fish bones, this process is done by using butyl alcohol, hexane or a detergent (Duan *et al.*, 2009; Nagai and Suzuki, 2000a; Wang *et al.*, 2008). Not only different in demineralization (Duan *et al.*, 2009) used different condition to perform acid treatment at carp fish. For the skin and scale, 0.1 M NaOH in 1:8 (w/v) sample/alkali solution was used under stirred for 6 h, while for bone the ratio was set into 1:5 (w/v).

An alternative approach to substitute acidic or alkaline pre-treatment by using enzymes in the production of gelatin from grass carp has been demonstrated by Zhang *et al.* (2010). In their work they use protease enzymes (after the removal of non-collagenous part by NaCl and demineralization using HCl) at a neutral pH and 20-40°C for 1-12 h. This produced a good quality gelatin with gel strength of 172-219 g. Several methods for gelatin and collagen isolation from fish bones and scales are presented in Table 1.

CHEMICAL PROPERTIES OF BONE AND SCALES GELATIN

Table 2 summarizes the amino acid composition of bone and scale based gelatins. In general, the amino acid composition of both fish scale and bone is almost similar to fish skin-based gelatin, and showed slight differences with commercial gelatin. With the exception of gelatin from pigskin origin, all other gelatins do not contain aspargine and glutamine. In addition, amino acid composition of fish scales and bone varied, particularly in cysteine content. Amino acids from pigskin gelatin and bone gelatins (Nile perch bone, commercial bones) do not contain cysteine. Gelatin from fish's bone and scale, in general have higher of imino acids (proline) content than the fish skin gelatin and almost the same with commercial gelatin from pigskin and bone. Muyonga *et al.* (2004) mentioned that the higher content of imino acid in Nile perch contributed to better gelling properties in their gelatin.

However, the content of hydroxyproline in fish skin gelatin is higher when compared with fish bone and scale gelatin as well as from commercial gelatin. For the content of glycine, which is the most common component in collagen, fish-based gelatin had lower quantities compared to those from mammalian sources (Wangtueai and Noomhornm, 2009; Zhang *et al.*, 2010; Liu *et al.*, 2008; Muyonga *et al.*, 2004; Kasankala *et al.*, 2007; Ledward, 2000), although Zhang *et al.* (2010) found a very high content of glycine in grass carp scale.

Arnesen and Gildberg (2002) mentioned that the lower concentration of hydroxyproline in fish compared to bovine and porcine accounts for the low gel strength in fish based gelatins. Nonetheless, Intarasirisawat *et al.* (2007) reported that heat-stable indigenous proteases were responsible for the degradation of gelatin molecules especially α and β-chains during extraction at elevated temperature; the results of this is low bloom value of gelatin.

Muyonga *et al.* (2004) compared gelatin extracted from young and adult bones of Nile perch and found that gelatin extracted from young bones had higher concentration of low molecular weight fraction compared to gelatins from old bones. Recent study carried out by Zhang *et al.* (2010) using grass carp scales and enzymatic treatment revealed that the lower the amino acids content of gelatin, the higher the α-chain and β-component.

PHYSICAL PROPERTIES OF FISH BONE AND SCALES GELATIN

The physical properties of fish bones and scales based gelatins are summarized in Table 3. The yield of gelatin extraction have been reported to range from 0.98-3.9% for bones and 9.1-10.9% for

Table 1: Procedures employed to isolate fish bones and scale gelatin/collagen

Raw material	Objective	Procedure	Reference
Skipjack tuna, Japanese sea bass, ayu, yellow sea bream, chub mackerel, bullhead shark and mackerel house bone	Collagen isolation	Pretreatment: Removal of non-collagenous proteins. Then decalcified. Washed with distilled water then defatted. Then washed and lyophilized. Collagen isolation: The insoluble matter was extracted by 0.5 M acetic acid (3 days) and centrifuged. The remaining insoluble matter re-extracted by same solution for 2 days and then centrifuged. The precipitation was carried out by salted out with NaCl (final conc. 0.9 M) followed by collagen isolation by salted out again until NaCl concentration reached 2.6 M in neutral pH. The solution then centrifuged, dissolved and dialyzed by acetic acid, distilled water then lyophilized.	Nagai and Suzuki (2000a)
Carp scales and bone	Collagen isolation	Pretreatment: Same as above then decalcified, defatted overnight. Collagen isolation: The extraction carried out by acetic acid 0.5 M, 1:4 (w/v) for 3 days followed by same solution 1:2.5 (w/v) for 2 days for bone. Scales at 1:2.5 (w/v) for 4 days. Then filtered, centrifuged and the supernatant then salted out until NaCl concentration reached 2.5 M. The solution then centrifuged, dissolved and dialyzed by acetic acid, distilled water then lyophilized.	Duan *et al.* (2009)
Deep-sea redfish scales and bone	Collagen isolation	Pretreatment: Soaked at 20 volumes 1 M NaCl for 24 hour then demineralized then defatted, washed and lyophilized. Collagen isolation: Extraction was undergone with 0.5 M acetic acid 1:100 (w/v) for 24 hour, stirred. Then centrifuged and re-extracted and re-centrifuge at same condition. Supernatant then salted out by NaCl until final concentration was 0.9 M. The solution then centrifuged, dissolved and dialyzed by acetic acid, distilled water then lyophilized.	Wang *et al.* (2008)
Black drum and sheepshead seabream bone and scales	Collagen isolation	Pretreatment: Soaked at NaOH 0.1 M for 24 h, stirred and re-soaked in 20 volumes of 0.1 M NaOH for 24 h. Collagen isolation: Solubilized at 0.5 M aceic acid containing 0.1% (w/v)pepsin for 3 days then centrifuged. Repeated under same condition then salted out by NaCl until 0.9 M final concentration. Centrifuged and repeated 3 times then dyalized.	Ogawa *et al.* (2004)
Rohu and Catla scales	Collagen isolation	Pretreatment: Washed with 1 M NaCl, 0.05 M tris HCL, 20 mM EDTA for 48 h. Demineralized and washed thrice. Collagen isolation: Treated with acetic acid 0.5 M for 48 h then salted out by NaCl until 0.9 M and kept for 24 h and centrifuged. These step were repeated thrice then dialyzed, distilled and freeze-dried.	Pati *et al.* (2010)
Snakehead fish bone	Gelatin isolation	Pretreatment: Degreasing at 80°C for 5 minutes, washed and minced. Immersed at acid solution for 24-48 hour until ossein formed. Extraction: Aqueous extraction at 70, 80 and 90°C for 5 h 1:3 (w/v). Filtrated then dried and crushed.	Arafah *et al.* (2008)
Grass carp scales	Gelatin isolation	Pretreatment: Washed with 10% (w/v) NaCl for 24 h. Demineralized, washed then dried and pulverized. Enzymatic treatment: Mixed with distilled water (1:10 w/v), adjusted to pH 7 for 1-12 hour at 20-40°C then added by protease 0.01-0.38 % w/w.	Zhang *et al.* (2010)

Table 1: Continued

Raw material	Objective	Procedure	Reference
		Extraction: Heated in distilled water at 60°C for 6 h, filtrated and freeze dried.	
Lizardfish scales	Gelatin isolation	Pretreatment: Treated with 0.1-0.9% NaOH at 30°C for 1-5 h. Neutralized by tap water. Extraction: Heated in distilled water 1:2 w/v at 70-90°C for 1-5 h. Then vacuum filtered, vacuum evaporated and vacuum dried.	Wangtueai and Noomhornm (2009)
Nile perch bone	Gelatin isolation	Pretreatment: Degreased and demineralized for 9-12 days. Extraction: Covered with warm (60°C) water by three sequential 5 h extractions at 50, 60 and 70°C, followed by boiling for 5 h.	Muyonga *et al.* (2004)
Channel catfish head bones	Gelatin isolation	Pretreatment: Demineralized, washed then treated with 0.1 M NaOH until the pH reached 10-11, subsequently treated with 9 g L^{-1} of $Ca(OH)_2$ for 144 h and agitated at 130 rpm. Extraction: In 75°C for 4 h in the solution of pH 4.0, the second and third gelatins were extracted on the condition of 82°C, pH 2.5, 2 h and 90°C, pH 3.0, 3 h. Filtrated, evaporated and dried.	Liu *et al.* (2009)

Table 2: Amino acids composition of several gelatins from fish bones and scales (/100 residues)

Amino acids	Lizardfish scales[a]	Grass carp scale[b]	Channel catfish head bone[c]	Nile perch bone[d]		Grass carp skin[e]	Pigskin gelatin[f] (acid pre-treated)	Commercial bones gelatin[f] (alkali pre-treated)	References
				Young fish	Adult fish				
Alanine	12.4±0.38	12.9	9.25	10.46±0.03	10.32±0.15	8.25	11.2	11.7	[a]Wangtueai and
Arginine	0.562±0.01	5.0	7.22	7.94±0.10	8.17±0.07	6.95	4.9	4.8	Noomhornm (2009)
Aspartic acid	3.80±0.41	4.7	5.59	4.67±0.08	5.17±0.22	4.84	2.9	4.6	[b]Zhang *et al.* (2010)
Cysteine	0.0006±0.00	0.1	2.82	-	-	0.04	-	-	[c]Liu *et al.* (2008)
Glutamic acid	8.85±0.41	7.7	10.52	9.41±0.01	9.42±0.07	9.11	2.5	7.2	[d]Muyonga *et al.* (2004)
Glycine	18.3±0.22	36.7	21.77	23.51±0.15	23.55±0.15	19.60	33.0	33.5	
Histidine	1.52±0.09	0.5	1.06	1.04±0.03	1.04±0.04	0.45	0.4	0.4	[e]Kasankala *et al.* (2007)
Hydroxylysine	0.565±0.03	-	-	1.72±0.01	1.42±0.11	-	0.6	0.4	
Hydroxyproline	3.92±0.48	7.0	7.51	9.67±0.03	9.76±0.26	11.27	9.1	9.3	[f]Ledward (2000)
Isoleucine	2.47±0.27	1.0	1.62	1.11 ±0.03	1.00±0.02	1.16	1.0	1.1	
Leucine	5.50±0.19	2.1	2.79	2.40±0.07	2.30±0.05	2.07	2.4	2.4	
Lysine	11.8±1.35	2.5	3.57	3.43±0.70	3.58±0.12	3.20	2.7	2.8	
Methionine	2.55±0.22	1.3	1.29	1.75±0.02	1.45±0.04	1.51	0.4	0.4	
Phenylalanine	11.0±0.32	1.3	1.94	2.24±0.07	2.15±0.07	1.96	1.4	1.4	
Imino Acid	16.5±1.12	8.7	13.08	12.27±0.03	12.00±0.26	8.20	13.2	12.4	
Serine	0.785±0.10	3.9	3.74	3.02±0.02	3.13±0.02	2.79	3.5	3.3	
Threonine	0.907±0.07	2.5	1.93	2.81±0.04	2.86±0.03	2.29	1.8	1.8	
Tryptophan	0.006±0.00	-	-	-	-	-	-	-	
Tyrosine	1.63±0.21	0.4	0.65	0.60±0.01	0.62±0.01	0.42	0.3	0.1	
Valine	2.72±0.23	1.8	2.57	2.12±0.01	2.05±0.02	1.84	2.6	2.2	
Aspargine	-	-	-	-	-	-	1.6	-	
Glutamine	-	-	-	-	-	-	4.8	-	

bovine gelatin was 322±4.56 (Wangtueai and Noomhornm, 2009). This study also mentioned that, the optimum conditions for gelatin extraction by alkaline pre-treatment was achieved using NaOH solution at a concentration of 0.51%, 78°C for 3.10 h treatment time and 3.02 h extraction time. Cheow *et al.* (2007) reported that gelatin from sin croaker and shortfin scad had low gel strength

Table 3: Physical properties of several gelatins from fish bones and scales (/100 residues)

Source	Yield(%)	Bloom Value (g)	Setting pointe (°C)	Melting pointe (°C)	Iscionic point	Viscosity	Color	References
Nile Perch bones							DGI	
Young	1.3wb	179	18.5	26.5	7	28.2	5.1	Muyonga *et al.*
Adult	2.4wb	134	19.0	25.5	7.2	30.0	4.0	(2004)
		Bovine (B) : 221	B: 25.3	B: 31.6		B: 46.0	B: 3.1	
		Comm. Fish (CF): 216	CF: 22.5	CF: 26.3		CF: 40.0(mSt)	CF: 3.1	
Lizardfish scales	9.1-10.9	268±5.39 B: 322±5.39	-	-	-	3.43-5.63cP	L: 75.1±0.11 a: 1.96±0.12 b: 11.8±0.35B L: 81.5±0.32 a: 1.87±0.09 b: 22.1±0.55	Wangtueai and Noomhorrm (2009)
Grass carp scales	-	276±12	-	26.9	7.0	-	-	Zhang *et al.* (2010)
Channel catfish	1st: 3.9±1.1	3.9±1.1	18.4	25.1				
head bone	2nd: 5.5±0.7	5.5±0.7	15.7	22.9	-	-	-	Liu *et al.* (2008)
	3rd: 8.4±2.4	8.4±2.4	13.3	20.7				
Snakehead fish hard bone	0.98-3.213	37.11-159.7	-	-	-	22.0-91.58 cPs	-	Arafah *et al.* (2008)

(of 124.94 and 176.92 g, respectively) compared to bovine gelatin 239.98 g (9.76±0.12 mg 100 g). Lower bloom value might be the biggest problem for gelatin from fish origin, although some works have indicated that fish skin had higher gel strength than bovine and porcine gelatin (Arnesen and Gildberg, 2002; Cho *et al.*, 2005).

High bloom value (gel strength) of some gelatin derived from fish bone is one of the advantages fish bone gelatin has over gelatin produce from fish skin. Zhou and Regenstein (2005) reported that Alaska pollock gelatin from fish skin have a bloom value of 98 g. Furthermore, a bloom value of 108 g for salmon and 71 g for cod (Arnesen and Gildberg, 2007), 124.9 g for Sin croaker (Cheow *et al.*, 2007), 128.1 g for red tilapia skins (Jamilah and Harvinder, 2002), 56 g for Bigeye snapper and 135.5 g for bigeye pepsin (Nanilamon *et al.*, 2008) and 105.7 for Brownstripe red snapper Jongjareonrak *et al.* (2005) have been reported. These values differ significantly with gelatin from porcine and bovine origin. Nonetheless fish products have a high potential to be used for gelatin. GEA (2010) showed that, gelatin is applied in various sectors in the industry based on different bloom grades (50-300) according to user needs.

Gelatins of fish bone and scales origin also have lower setting and melting point which has been reported to range from 13.3-19 and 20.7-26.9, respectively; as well as the viscosity (28.2 and 30.0) compared with gelatins of bovines and commercial fish origin, which ranges from 22.5-25.3 and 26.3-31.6, respectively as well as the viscosity (40.0 and 46.0 mSt), yet the isoionic point of fish bone ad scale gelatin are stable at 7.0-7.2 (Muyonga *et al.*, 2004; Liu *et al.*, 2008).

IMPROVEMENT OF FISH ORIGIN GELATIN

The low yields of gelatin obtained from fish by-products compared to gelatin from other sources are issues of concern. A number of studies have been carried out to address this challenge. For instance, Gudmunsson and Hafsteinsson (1997) mentioned that the quality of gelatin can be controlled to the desired standard by manipulating pre-treatment and processing conditions. The

same researchers also reported that, a treatment combination of citric acid, low concentration of sulfuric acid and sodium hydroxide resulted in a higher yield (14%) compared to 11% when a high concentration of citric acid (>1%) and sulfuric acid, and NaOH (>2%) were used. Arafah *et al.* (2008) also showed that, a higher concentration of acid, together with increased extraction temperature did lower the gelatin yield of mackerel fish skin. Zhang *et al.* (2010) used enzymatic treatment for grass carp scales and concluded that, gelatin from grass carp scales can be made into good quality gelatin which will have high gel viscoelastic property at lower temperature and good quality gel strength (276±12 g) compared to commercial porcine gelatin. Aewsiri *et al.* (2009) reported that fish products can be subjected to bleaching to enhance the quality of the gelatin. Thus in their study, they employed H_2O_2 as a bleaching agent in gelatin production from cuttlefish, and found higher yield, brighter color and effective increase in gel strength. Fernandez-Diaz *et al.* (2003) mentioned that gelatin extracted from lower temperature storage fish skin had higher gel strength compared to samples that stored at higher temperature. Bhat and Karim (2009) also observed that UV irradiation increased the gel strength of fish gelatin.

CONCLUSION

Production of gelatin from fish bones and scales are important alternative source for fish skin gelatin. Although the resulting yield from fish bone and scales gelatin is lower than that obtained from fish skin, the quality of gelatin produced is not inferior when compared. Nonetheless several studies have indicated that gelatins produced from fish bones and scales have acceptable gel strength (bloom value). Weak gel strength and low melting point, makes gelatin derived from fish unable to be used completely to replace the role bovine and porcine gelatin plays. With the development of research, various solutions such as enzyme-aided processes, combination of acid-alkali solutions and gelatin bleaching processes have been found to improve the quality of gelatin from fish bone and scales.

Preparation of gelatin from fish by-products is a way of utilizing the huge waste created by the fish industry into useful products. It also has the advantage of being accepted with ease as Halal and Kosher food.

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