Physicochemical Properties of Silver Catfish (*Pangasius sutchi*) Skin Gelatin Produced as Affected by Different Extraction Time

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Abstract

Gelatin was extracted from silver catfish (*Pangasius sutchi*) skin and the effects of extraction time on the physicochemical characteristics of the gelatin were studied in comparison with commercial bovine gelatin. The skin was initially pre-treated by washing in 0.19N NaOH and 0.12N acetic acid prior to gelatin extraction at 50°C for 6, 8, 10 and 12 hrs. The extracts were filtered, freeze dried and then ground. Yield was recorded and the gelatin was analysed for viscosity, molecular weight distribution, amino acids composition, gel strength, melting point, setting point and setting time. Longer extraction time resulted in higher gel strength and melting point while the gel sets at lower temperature and requires shorter setting time than commercial bovine gelatin. The yields were 10.40% and 11.42% at 10 and 12 hrs extraction time, respectively. Extracted gelatins showed higher gel strength and contain higher amount of proline, lysine, phenylalanine and glycine than the commercial bovine gelatin. High molecular weight bands between 80 to 175 kDa were observed in all the extracted gelatins. Therefore, in this study, 10 hrs extraction time is considered as the optimum duration for silver catfish gelatin production as it produces gelatin with high gel strength and viscosity values as well as acceptable yield. In view of its high gel strength and viscosity value, silver catfish skin gelatin has the potential to be used as gelling agent in food.

Keywords: Silver catfish *(Pangasius sutchi),* gelatin, extraction time, gel strength, viscosity

Introduction

Silver catfish (*Pangasius sutchi)* is one of the popular freshwater fish used as food in Malaysia (Mohsin and Ambak, 1983). They are found abundantly in the Amazon River, parts of Russia, Bangladesh, Indonesia, India and Thailand. In Malaysia, they are known as 'patin' and the names varied from place to place around the world such as 'pa sooai' and 'pa sooai khaeo' in Laotian, 'pla sawai' in Thai, 'pra' and 'trey pra' in Khmer and 'ca tra' in Vietnam (Bui *et al.,* 2010; Phan *et al.,* 2009; Abbas *et al.,* 2006). Silver catfish is a fast growing fish where it is usually cultured in ponds, floating cages and pens (Phuong and Oanh, 2010).

Most commercial gelatin in the world derived from pigskin and bovine hide (Gómez-Guillén *et al.,* 2011). Gelatin can also be extracted from the denatured collagen of fish skin (Montero *et al.,* 1995). According to Gómez-Guillén *et al.,* (2002), gel strength and thermostability of gelatin mostly depend on the amino acid composition and the molecular weight distribution of the gelatin which mainly influenced by the processing condition. Gelatin quality and its potential application are influenced by the gelatin physical properties which are related to gelatin structure (Yang and Wang, 2009). Gilsenan and Ross-Murphy (2000) pointed out that gelatin from tropical and sub-tropical warm-water fish species such as Nile perch, catfish and tilapia have similar rheological properties and thermostability to that of mammalian gelatins depending on the processing conditions used.

High market demand for fisheries product could lead to excessive amount of waste produced. Processing discards from fisheries account for as much as 70 to 85% of the total weight of catch and 30% of the waste are in the forms of bones and skins with high collagen content (Shahidi *et al.,* 1994). By-products from freshwater fish are seldom examined as a source of materials for gelatin extraction (See *et al.,* 2010; Jongjareonrak *et al.,* 2010; Jamilah *et al.,* 2011). Silver catfish skin can be used as a source of gelatin which is acceptable for halal status to produce gelatin that is safe and acceptable for the halal status. Furthermore, catfish gelatin showed higher gel strength and protein content compared to other fish (See *et al.,* 2010; Jamilah *et al.,* 2011; Mahmoodani

et al., 2014). Extracted gelatin from fish can also contribute in enhancing flavor release, fruit aroma and melt rate in water gel desserts thus improve the gelatin attractiveness. Studies on the effect of extraction time on the quality of silver catfish skin gelatin were still limited. Optimizing the extraction time may result in optimum production of gelatin with good gel strength in addition to some other beneficial properties. Therefore, this study was carried out to determine the physicochemical properties of silver catfish skin gelatin extracted at different periods of time and to compare the gelatin obtained with the commercial bovine gelatin.

Materials and methods

Materials

Silver catfish with the average weight of 800 to 1000 g per fish was obtained from a local freshwater fish breeder in Selayang, Selangor. Commercial bovine gelatin was obtained from the Halagel Company, Sungai Petani, Kedah. All chemicals used were of analytical grade.

Extraction of gelatin from silver catfish

Initial preparation involved de-skinning of the fish. Adhered tissues on the skin were manually scraped off. The skin was then cut into 2 to 3 cm^2 with knife followed by washing under tap water. Gelatin was extracted according to the method of Tabarestani *et al.,* (2010). After washing, the skin was pre-treated by soaking in 0.19 N cold NaOH at 1:3 (w/v) for 40 minutes to remove any non-collagenous protein followed by rinsing in tap water. It was then soaked in cold acetic acid solution (0.12 N) at the ratio of 1:3 (w/v) for 40 minutes and subsequently rinsed until a pH of 7 was achieved. To extract the gelatin, the swollen skin was soaked in distilled water (50 °C) in a temperature-controlled water bath (Memmert W350, Schwabach, Germany) for 6, 8, 10 and 12 hrs with a continuous stirring at a speed of 150 rpm. The extract was then filtered and dried in a freeze drier (Alpha 1-4, Germany). The collected gelatin was then ground into a powder and kept for further analysis.

Analysis of Gelatin

Yield

The percentage of gelatin yield was obtained by using the method used by Binsi *et al.,* (2009) based on wet weight of the skin using the following formula:

$$\text{Yield (\%)} = \frac{\text{Weight of powdered gelatin} \times 100}{\text{Wet weight of fresh skin}}$$

Amino acids composition

Amino acids composition was analyzed according to the method by Pranoto *et al.,* (2011). Sample (0.1g) was hydrolysed in 5 ml of 6N HCl at 110°C for 24 hrs. The hydrolysate was filtered through Whatman filter paper No. 42. Alpha-aminobutyric acid (AABA) (4 ml) was added into 2ml filtrate and made up to 10 ml using deionized water. The sample was then filtered through a nylon membrane filter (0.45 µm). The filtered sample (10 µl) was then mixed with 70 µl borate buffer and 20 µl HPLC grade (AccQ Tag Fluor reagent) and left for 1 minute. Subsequently, 5 µl of the mixture was injected into the HPLC system (Waters 1525, U.S.A) equipped with fluorescence detector (Waters 2475, USA) and AccQ Tag reverse phase C18 column (3.9 × 150 mm). Mobile phase used were AccQ Tag Eluent A and 60% acetonitrile (Eluent B) with flow rate of 1 mL/min.

Molecular weight distribution

Sodium dodecyl sulphate polyacrylamide gel electrophoresis (SDS-PAGE) with 5% stacking gel and 12% resolving gel was used to determine the molecular weight distribution according to the method of Fengxiang *et al.,* (2011). Gelatin (10 µl), skin and commercial gelatin solution which was initially mixed with sample buffer at 1:1 ratio was loaded into each well of the SDS-PAGE (Omni PAGE mini, Lonza, USA). Constant current of 200 volt was supplied during the electrophoresis that was run for 1 hr. The gel was washed using deionized water for 30 minutes using incubator shaker and then stained in Coomassie Brilliant Blue R-250 by soaking the gel for 1 to 6 hr. Destaining process was carried out by rinsing in deionized water until the zone on the blue background was clear.

Viscosity

Gelatin was mixed with distilled water at 6.67% (w/v) and heated at 60°C to dissolve the gelatin. Viscosity was measured by inserting the gelatin solution into the Brookfield DV-I viscometer (U.S.A) with spindle No.1 at 100 rpm. The temperature was set at 60°C and occasionally reduced every 1°C until the solution was gelling (Arnesen and Gildberg, 2002). The viscosity of the commercial gelatin was also measured in a similar manner.

Gel Strength

The gel strength of silver catfish skin gelatin and commercial gelatin were determined according to Gómez-Guillén *et al.,* (2002) and See *et al.,* (2010). 6.67% (w/v) Gelatin was mixed in water and heated at 60°C to completely and the solution was left at room temperature for 30 min to allow the gelatin to absorb water and swell. The mixture was heated at 60°C to completely dissolve the gelatin. The gelatin solution was then transferred into a bloom jar (3.3 cm diameter and 6 cm height) and kept in a refrigerator at 7ºC for 16 to 18 hrs for gel maturation. The gel strength of the gelatin was determined by using the TAXT2 Texture Analyzer (Stable Micro System, UK) equipped with a flat-faced cylindrical Teflon plunger (1.27 cm in diameter) and load cell of 5kN. The maximum force (g) at the penetration depth of 4 mm was recorded at a rate of 2 mm/s. The measurements were performed in triplicate.

Melting Point

The melting points for silver catfish skin gelatin and commercial gelatin were determined using thin wall screw-cap test tubes (12 mm x 75 mm) (Muyonga *et al.,* 2004). A gelatin solution (6.67%) was prepared until it swelled and dissolved as previously mentioned and then filled into a test tube up to 15 mm headspace. The test tube was closed and held in refrigerator (7 ºC) for 16 to 18 hrs after which the test tube was transferred into a beaker containing warm water set at 10°C by using cold water. The test tube was inverted so that the headspace was at the bottom. The temperature of the water was then increased slowly by adding warm water. The melting temperature was recorded when the gel slipped down to the headspace.

Setting Point and Setting Time

The setting points for silver catfish skin gelatin and commercial gelatin were determined according to Muyonga *et al.,* (2004). 10% (w/v) gelatin solution was prepared in warm water bath (40 °C). Thirty millilitre of the gelatin solution was transferred into a test tube (12 mm × 75 mm) which was placed in a beaker containing water set at 40°C. The temperature was reduced by addition of cold water at 15 s intervals. A glass rod (diameter, 0.35 cm; length, 20cm) was inserted into the solution. The setting point was recorded when the gelatin solution no longer dripped from the tip of the rod.

Setting time was determined according to Muyonga *et al.,* (2004) and Kittiphattanabawon *et al.,* (2010). The test tube containing the gelatin solution and an aluminium needle (diameter, 0.1 cm; length, 8.5 cm) was placed in a beaker of cold water at 4°C and 10°C. The temperature was raised every 15 s by adding warm water. The setting time was recorded when the needle could not detach from the gelatin.

Data analysis

Data were subjected to analysis of variance (ANOVA) using Statistical Package for Social Sciences, SPSS version 15.0 (SPSS, 2006). Duncan's multiple range tests were performed to determine significant differences between means.

Results and discussion

Yield

The yields of silver catfish skin gelatin extracted at 6, 8, 10 and 12 hrs at 50°C are presented in Table 1. The highest yield was achieved at 12 hrs (11.42%) followed by a decreased with time. Gómez Guillén *et al.,* (2002) obtained 8.3% gelatin from sole after an overnight extraction at 45°C. See *et al.,* (2010) reported 10.78% when *Pangasius sutchi* gelatin was extracted at 45°C for 18 hrs. Silver catfish skin gelatin yield was close to these reports when shorter extraction time was used which are 6 and 8 hrs. This was probably due the slightly higher temperature used (50°C) in silver catfish gelatin extraction. Gelatin yield is also influenced by the species and age of the fish. Young fish aged less than 6 months gives lower yield compared to the adult fish aged 6 months and above (Tabarestani *et al.,* 2010; See *et al.,* (2010). In this study silver catfish aged around 6 months was used. During the extraction process, the skins were pre-treated in 0.19 NaOH and 0.12N acetic acid. Alkaline and acid treatments caused the skin to swell thus giving a high gelatin yield due to damage of certain cross-linkages within the collagen (Zhou and Regenstein, 2005).

Table 1. Yield (%) of silver catfish skin gelatin.

Extraction time (hr)	Yield (%)
6	8.20
8	8.12
10	10.40
12	11.42

Viscosity

The viscosities of commercial and silver catfish gelatin extracted at the duration of 6, 8, 10 and 12 hrs at 50°C and the commercial gelatin are shown in

Figure 1. All the gelatins exhibited constant viscosities until about 34°C which then began to increase non-uniformly at 26°C where gelatin extracted at 6 hrs (104.00 cP), 8 hrs (81.33 cP) and 10 hrs (80.00 cP) were more viscous than the bovine (44.00 cP) and 12 hrs (46.67 cP) gelatin. This suggested that the gelatins extracted at 6, 8 and 10 hrs started to gel faster than the gelatin extracted for 12 hrs. The viscosity results corresponded with the electrophoretic profile where the 12 hrs gelatin exhibited less intense β-chain band (Figure 2). The lower the content of high molecular weight fraction (>β), the lower the viscosity (Muyonga, 2004).

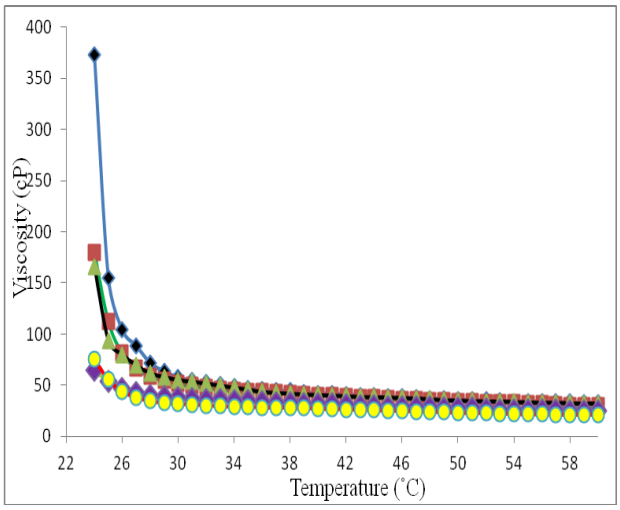

Figure 1. Viscosity of silver catfish gelatin extracted at different time; 6 hrs (◆), 8 hrs (■), 10 hrs (▲), 12 hrs (◆) and commercial gelatin (●).

According to Muyonga *et al.*, (2004) gelatin extracted from adult Nile perch aged more than 80 days old exhibited higher viscosity compared to young fish aged less than 80 days old. Silver catfish used in this experiment were around 6 months old which is considered as within the range of an adult fish. Jamilah and Harvinder (2002) reported that black tilapia gelatin recorded twice the viscosity value (7.12 cP) compared to red tilapia which was only 3.20 cP at room temperature. The viscosities for yellowfin tuna, brown stingray, red snapper and white cheek shark gelatins ranged between 6.64 to 8.00 cP at room temperature (Pranoto *et al.*, 2011). Hence, viscosity of gelatin is influenced by the age and species used for the extraction. The viscosity of gelatin is also closely related to the length of polypeptide chain (See *et al.*, 2010).

Molecular weight distribution

The molecular weight distribution among the commercial bovine gelatin, silver catfish skin and silver catfish skin gelatin with various extraction times were compared (Figure 2). All the extracted silver catfish skin gelatins showed bands approximately from 80 to 175 kDa. Silver catfish skin had molecular weight bands approximately from 39 kDa to 175 kDa. Commercial gelatin shows only one α-chain at 125 kDa where the corresponding chain almost disappeared.

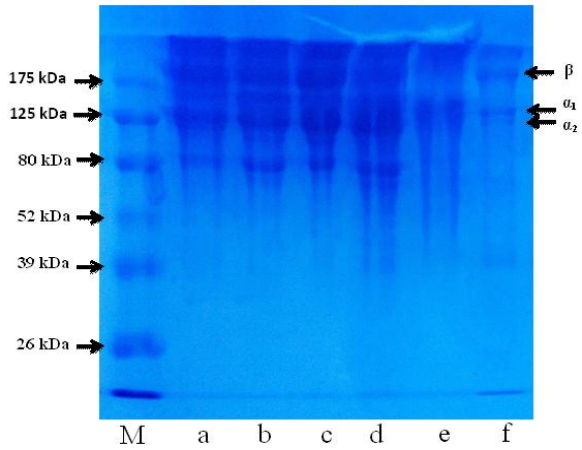

Figure 2. Electrophoresis profiles of silver catfish gelatins extracted at a) 6 hrs, b) 8 hrs, c) 10 hrs and d) 12 hrs. Lane e) commercial bovine gelatin and f) silver catfish skin. M is protein marker.

The α and β-chain can clearly be observed in the 6, 8, and 10 hrs extracted silver catfish skin gelatin whereas in the 12 hrs extracted gelatin only α-chain can be seen while the β-chain seems slightly unclear. According to Karim and Bhat, (2009), high molecular weight subunits give negative effect on some of the functional properties of the gelatin such as lower gel strength and melting point. Silver catfish skin gelatins extracted at 6, 8 and 10 hrs which are characterized by the presence of high molecular weight band (175 kDa) had lower gel strength and melting point than those extracted at 12 hrs (Table 3). Tavernier (1989) stated that viscosity, film strength and bloom properties are highly correlated with the β-chain while the α-chain was correlated with the melting and setting temperatures. Jongnareonrak *et al.*, (2010) observed the α, β and γ-chain in giant catfish skin gelatin where the α-chain had molecular weight of approximately 100 kDa. High proportion of α and β-chain has been reported in Nile perch skin gelatin (Muyonga *et al.*, 2004) and also from Alaska pollock gelatin (Zhou *et al.*, 2006). Skin pre-treatment in 0.21N NaOH and 0.21N acetic acid

increased the α-chain in the extracted gelatin (Tabarestani *et al.*, 2010). According to Zhou and Regenstein, (2005), alkaline extraction caused some polypeptide chains in collagen to break into small pieces. In neutral or weak acid conditions, gelatin fraction gives the α and β-chains (Gómez-Guillén *et al.*, 2002).

Amino acid

Amino acids composition of silver catfish skin, silver catfish skin gelatin and commercial gelatin (bovine) are shown in Table 2. Silver catfish skin contain higher amount of proline (49.319), phenylalanine (32.756), glycine (28.256) and lysine (19.503) as opposed to other amino acids. Aspartic acid, histidine, arginine and valine were not detected in the commercial gelatin whereas sixteen types of amino acids were detected in silver catfish skin gelatin. Gelatin extracted at 6 hrs showed higher amount of proline than other amino acids. The total amount of glycine and proline in silver catfish skin gelatin were 50.45, 39.96 and 7.34g per 100g, respectively, for 6, 10 and 12 hrs of extraction. Glycine and proline content were high in 6 hrs gelatin compared to 12 hrs gelatin which is in-line with the viscosity result (Figure 1).

Table 2. Amino acids composition (g per 100g) of silver catfish skin, silver catfish skin gelatin and commercial gelatin.

Amino acid	g per 100 g					
	Commercial bovine gelatin	Silver catfish skin	Extraction time (hrs)			
			6	8	10	12
Asp	ND	0.371	0.505	0.116	0.985	0.113
Ser	0.170	1.181	0.124	0.009	0.078	0.567
Glu	0.434	0.065	0.045	0.023	0.178	0.014
Gly	0.813	28.256	17.268	0.582	23.481	4.565
His	ND	0.045	4.023	0.048	0.095	0.201
Arg	ND	18.862	4.793	0.817	2.108	8.574
Thr	1.109	8.600	0.604	0.100	0.370	0.179
Ala	0.582	4.522	2.151	0.017	0.702	0.479
Pro	1.584	49.319	33.181	0.585	16.476	2.777
Tyr	8.022	1.185	8.260	0.017	2.073	0.255
Val	ND	1.528	0.429	0.585	0.924	0.057
Met	0.367	0.596	0.094	0.006	0.264	3.419
Lys	0.772	19.503	13.241	0.562	17.778	0.330
Ile	0.369	1.005	0.160	0.006	0.177	0.027
Leu	0.296	0.628	0.216	0.005	0.167	0.055
Phe	0.366	32.756	27.117	18.111	16.011	15.927

ND: not detected

According to Gómez-Guillén *et al.*, (2002), gelatin which contains high composition of proline shows better viscoelastic properties. As glycine and proline residues decreases in gelatin, the stability of the collagen fibers and denaturation temperature also reduced (Toshiyuki *et al.*, 2003). According to Arnesen and Gildberg (2007) the important factor affecting the rigidity of gelatin structure was the total amount of glycine, proline and hydroxyproline. Lysine stabilizes the gelatin structure by forming cross-linkages between chain and maintaining the triple helical structure of collagen in the gelatin (Cho *et al.*, 2004). Liu *et al.*, (2008), stated that high content of lysine improved the rheological properties of the gelatin. Lysine content in silver catfish gelatins was high when gelatin was extracted at 6 and 10 hrs.

Gel Strength

Gel strength is one of the most important functional properties of gelatin and the quality of gelatin is determined by its value (Mohtar *et al.*, 2010). Fish gelatin typically had gel strength ranging from as low as 0 to 426 g compared to 200 to 300 g for bovine and porcine gelatin (Karim and Bhat, 2009). Table 3 shows that the gel strength of silver catfish skin gelatin increased with the increase of extraction time up to 10 hrs of extraction. However, there was no significant difference ($p<0.05$) between the 10 and 12 hrs extraction. Glycine, proline and hydroxyproline affect the rigidity of gelatin structure while high content of lysine improved the rheological properties of the gelatin (Arnesen and Gildberg 2007; Liu *et al.*,

2008). The high gel strength values of the less than 10 hrs silver catfish gelatin in comparison to the commercial gelatin could be associated with the high content of proline, glycine and lysine. Commercial bovine gelatin gel strength was significantly ($p<0.05$) lower (364.13 g) than that of silver catfish gelatin (451.69 to 585.62 g).

Table 3. Gel strength and melting point of commercial gelatin and silver catfish skin gelatin extracted at different time.

Samples	Gel strength (g)	Melting point (°C)
Silver catfish gelatin (6 hrs)	451.69 ± 12.56^{c}	31.5 ± 1.80^{c}
Silver catfish gelatin (8 hrs)	512.65 ± 12.02^{b}	32.0 ± 1.32^{c}
Silver catfish gelatin (10 hrs)	564.88 ± 6.94^{a}	34.8 ± 0.76^{ab}
Silver catfish gelatin (12 hrs)	585.62 ± 9.16^{a}	36.8 ± 0.76^{a}
Commercial bovine gelatin	364.13 ± 2.24^{d}	33.7 ± 1.15^{bc}

Values represent means of three replicates ±standard deviation.
Means within the same column with different superscript letters are significantly different ($p<0.05$).

The gel strengths of warm water fish gelatin were 267 g (grass carp), 328 g (tilapia), 426 g (yellowfin tuna), 252 g (catfish), 328 g (Nile tilapia) and 229 g (Nile perch) (Cho *et al.,* 2005; Yang *et al.,* 2007; Songchotikunpan *et al.,* 2008; Muyonga *et al.,* 2004). Gelatin from cold-water fish species such as salmon, cod, hake and Alaskan pollock generally showed lower gel strength ranges from 70 to 110g compared to 273g and 307 g for bovine and porcine, respectively (Arnesen and Gildberg, 2007; Gomez-Guillen *et al.,* 2002; Zhou *et al.,* 2006; Mohtar *et al.,* 2010). According to Holzer (1996), the gel strength of commercial gelatin ranges from 100 to 300 g, however, gelatin with gel strength of 250 to 260 g is most desirable and suitable for wide range of applications in food industry (Mohtar *et al.,* 2010). Gelling properties of gelatin are influenced by the raw materials which vary in proline and hydroxyproline contents (Jongjareonrak *et al.,* 2006). Mammalian gelatins generally had high amount of hydroxyproline and proline (Benjakul *et al.,* 2009). The proline and hydroxyproline contents of approximately 30%, 22 to 25% and 17% for mammalian, warm-water fish and cold-water fish gelatins, respectively, have been reported (Muyonga *et al.,* (2004). According to Nalinanon *et al.,* (2008) fish gelatin has lower hydroxyproline contents from about 7 to 10% of the total amino acids compared with that of bovine gelatin (14%).

Gel strength also depends on the pre-treatment and conditions employed during the extraction of gelatin (Gime´nez *et al.,* 2005; Muyonga *et al.,* 2004; and Cho *et al.,* 2005). According to Zhou and Regenstein (2005), alkaline and acidic pre-treatments effectively removed the non-collagenous proteins causing a significant swelling of fish skin and securing a high gelatin yield and gel strength. Go´mez-Guille´n and Montero, (2001) obtained better gelling gelatin using diluted acetic acid instead of citric acid. Adjusting the pH of the gelatin close to its isoelectric point where the protein chains will be more neutral and the gelatin polymers are closer to each other results in the formation of more compact and stiffer gel (Gudmunsson and Hafsteinsson, 1997).

Melting point

Melting point is the temperature at which a gel becomes liquid. The melting points of silver catfish skin gelatin obtained after extraction at different time increased with increase in extraction time (Table 3). The melting point of silver catfish gelatin ranged from 31.5 to 36.8°C while commercial gelatin melted at 33.7°C. According to Choi and Regenstein (2000) the increase in gel strength of a gelatin gel is accompanied by an increased in melting point. This is in agreement with silver catfish gelatin (Table 3). Melting points are influenced by the proline and hydroxyproline content, molecular weight distribution, gel maturation temperature and fish species (Mohtar *et al.,* 2010; Gilsenan and Ross-Murphy, 2000; Choi and Regenstein, 2000; Pranoto *et al.,* 2011). Previous studies showed that bovine and porcine gelatins had considerably higher melting points than most fish gelatin (Choi and Regenstein 2000; Gilsenan and Ross-Murphy, 2000; Gudmundsson, 2002; Leuenberger, 1991). In this study, 12 hrs of extraction produced silver catfish skin gelatin characterised by significantly ($p<0.05$) higher melting point than the commercial bovine gelatin (Table 4).

Setting point and Setting time

Setting point of a gelatin solution is the temperature at which it becomes gel. Silver catfish gelatin had setting point range from 14.7 to 16.6°C which are significantly ($p<0.05$) lower than commercial gelatin which set at 20.2°C (Table 4). Table 3 and 4 showed that silver catfish gelatin requires lower temperature

and shorter time to set with increased in extraction time which negatively correlates with gel strength. However, Kittiphattanabawon *et al.,* (2010) studies showed no difference in setting time between 6 and 12 hrs extraction when the gelatins were extracted at both 45 and 60°C. Commercial bovine gelatin required longer time to set than silver catfish gelatin. Differences in setting time among gelatin might be caused by differences in molecular weight distributions (Muyonga *et al.,* 2004).

Table 4. Setting point and setting time of commercial gelatin and silver catfish skin gelatin extracted at different time.

	Setting point (°C)	Setting time at 10°C (min)	Setting time at 4°C (min)
Samples			
Silver catfish gelatin (6 hrs)	16.6±0.36^{b}	8.2±0.26^{b}	5.5±0.90^{b}
Silver catfish gelatin (8 hrs)	16.1±0.53^{bc}	6.2±0.91^{c}	5.1±0.10b^{c}
Silver catfish gelatin (10 hrs)	15.8±0.25^{bc}	5.8±0.49^{c}	4.4±0.54b^{c}
Silver catfish gelatin (12 hrs)	14.7±0.58^{c}	3.7±0.27^{d}	4.1±0.88^{c}
Commercial bovine gelatin	20.2±1.15^{a}	9.8±0.48^{a}	6.9±0.35^{a}

Values represent means of three replicates ±standard deviation.
Means within the same column with different superscript letters are significantly different ($p<0.05$).

Conclusions

Gelatin was successfully extracted from silver catfish (*Pangasius sutchi*) skin at 50°C at different time and compared to the commercial bovine gelatin. Extraction of silver catfish skin gelatin between 6 to 12 hrs resulted in reasonably good yield and good properties in terms of gel strength, melting point, setting point and setting time. Therefore, silver catfish gelatin is suitable to be applied in various areas in food processing and has the potential to be commercialized as an alternative to commercial bovine Gelatin.

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