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Gelatin

Improving the Texture of Sardine Surimi using Duck Feet Gelatin

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ABSTRACT

Sardine surimi is classified as a low grade surimi due to its relatively poor texture quality. The objective of this study was to improve the texture quality of sardine surimi by adding duck feet gelatin. Duck feet gelatin were treated using four treatments (hydrochloric acid (SHCl), acetic acid (SAa), lactic acid (SLa), or citric acid (SCa)) before added to surimi which was prepared using sardine fish to study the effects of the additives on the quality properties (folding, gel strength, texture profile, expressible moisture (EM) content, and colour) of surimi gels. All sardine surimi samples containing gelatin showed improved texture quality compared to samples without gelatin. The folding test score increased from 1 to 4, the hardness value increased from 1103.69 g to 2579.86 g for SHCl, 5897.08g for SAa, 2713.48 g for SLa, and 6532.18 g for SCa. Gel strength improved from 1857.43 g.mm to 6655.57 g.mm, 6680.52 g.mm, 6928.21 g.mm, and 7290.00 g.mm for SHCl, SAa, SLa, and SCa, respectively. The addition of gelatin also increased the whiteness and decreased the EM of surimi gels. These findings show that duck feet gelatin has great potential for use as a protein additive for the improvement of the texture quality of sardine surimi.

Keywords: Protein additives, duck feet, sardine, texture

ABSTRAK

Surimi sardin diklasifikasikan sebagai surimi bergred rendah disebabkan kualiti tekstur yang kurang baik. Objektif kajian ini adalah untuk meningkatkan kualiti tekstur surimi sardin dengan penambahan gelatin kaki itik. Gelatin kaki itik dirawat menggunakan empat jenis rawatan (asid hidroklorik (SHCl), asid asetik (SAa), asid laktik (SLa), dan asid sitrik (SCa)) sebelum ditambah kepada surimi yang diperbuat daripada ikan sardin untuk menguji kesannya ke atas ciri-ciri kualiti gel surimi (ujian lipatan, kekuatan gel, analisis profil tekstur, tekanan kelembapan, dan pengukuran warna). Kesemua surimi sardin yang ditambah dengan gelatin berupaya meningkatkan kualiti tekstur surimi. Skor bagi ujian lipatan meningkat dari 1 ke 4. Nilai kekerasan turut meningkat dari 1103.69 g kepada 2579.86 g untuk SHCl, 5897.08g untuk SAa, 2713.48 g untuk SLa dan 6532.18 g untuk SCa. Kekuatan gel meningkat dari 1857.43 g.mm kepada 6655.57 g.mm, 6680.52 g.mm, 6928.21 g.mm dan 7290.00 g.mm masing-masing untuk SHCl, SAa, SLa dan SCa. Penambahan gelatin juga meningkatkan nilai keputihan untuk gel surimi dan merendahkan tekanan kelembapan bagi gel-gel surimi. Penemuan ini menunjukkan gelatin kaki itik mempunyai potensi yang tinggi sebagai alternatif kepada aditif protein untuk peningkatan kualiti tekstur surimi sardin.

Kata Kunci: Aditif protein, kaki itik, sardin, tekstur

INTRODUCTION

Surimi is minced fish obtained from fish flesh that has been mechanically deboned, washed, mixed with cryoprotectant, and kept frozen to maintain its quality. Lean fish have been used traditionally to produce surimi but those species are insufficient to meet demand due to overexploitation (Shitole *et al.*, 2014). Under-utilised small pelagic fish species such as sardines offer an alternative source of fish flesh, but their use for surimi production is limited because of quality issues, such as darker coloured tissues, poorer gel properties (Kudre *et al.*, 2013), and large quantities of lipids and myoglobin. However, protein additives can be used to enhance the gel strength of surimi (Benjakul *et al.*, 2004). For example, Binsi *et al.* (2009) reported that the gel-forming ability of fish mince could be substantially increased by the addition of gelatin at the 0.5% level.

One-third of total proteins in the body are contained in skin, tendons, and connective tissues, which are composed of collagen. Gelatin is derived from collagen, which is produced by partial hydrolysis, and has unique properties. It is especially valued in the meat industry, where it is a useful additive for improving quality characteristic of some meat products.

Traditionally, gelatins have come from mammalian sources such as pigs and cattle (Kittiphattanabawon *et al.*, 2010), but the spread of bovine spongiform encephalopathy (BSE) and laws against consuming pork or beef in some religions have led to the search for alternative sources of gelatin (Badii and Howell, 2006).

Alternatives to mammalian gelatin include marine sources (e.g., fish, jellyfish) and poultry (e.g., chickens, ducks). Gelatins from marine sources are not associated with the risk of BSE, can be used with minimal restrictions by Jews and Hindus, and are acceptable for consumption by Muslim people. However, their mechanical properties are not as good as those of mammalian gelatin (Karim and Bhat, 2009).

Poultry by-products, including skin and feet, contain large amounts of collagen, and they are expected to be one of the main sources of gelatin in the near future. According to the FAO (2014), Malaysia is one of the top producers of duck meat, and Asia accounted for 80.5% of total duck meat production around the world from 1992 to 2012. Thus, duck feet, which are a by-product of the industry, have great potential as a source of gelatin due to the abundant production of duck meats (Huda *et al.*, 2013a; Huda *et al.*, 2013b).

Several research groups have studied the effects of adding protein (i.e., gelatin) to surimi (Binsi *et al.*, 2009; Hernández-Briones *et al.*, 2009; Kaewudom *et al.*, 2012). Although Huda *et al.* (2013b) recently studied the addition of collagen into threadfin bream and sardine surimi, to date there are no reports about the addition of duck feet gelatin into low grade surimi such as sardine surimi. The objective of this study was to determine the effect of adding duck feet gelatin treated with four different acids as an additive to improve the texture quality of sardine surimi.

MATERIAL AND METHODS

Duck feet material

Duck feet were purchased from Perak Duck Food Industries Sdn. Bhd, Malaysia, Perak. The raw materials were transported to the laboratory in ice and stored at -20°C prior to use. All chemicals and reagents used were analytical grade.

Extraction of duck feet gelatin

Duck feet were thawed in a chiller overnight. They were cut into small pieces after the claws were removed and ground using a meat grinder (Model EVE/ALL-12, Rheninghaus, Torino, Italy). Next, 100 g of ground duck feet were washed before being defatted using 10% butanol w/v (1/20) for 12 h with continuous stirring. After defatting process, the sample was washed for ~ 5 min to remove residue of butanol. Samples were then treated with four different acid solutions, separately (0.1 M hydrochloric acid, acetic acid, lactic acid, and citric acid) at a ratio of 1:10 (w/v) for 24 h at 7°C . The treated duck feet were neutralized with flowing tap water prior to the extraction process.

Gelatin extraction was performed based on Kim *et al.* (2012) with some modifications. Gelatin was extracted with ratio 1:2 (w/v) in a beaker at 75°C for 2 h. The gelatin obtained was filtered using Whatman filter paper No. 4, and the filtrate was frozen before being lyophilized (Labconco Freezedry System, Kansas City, MO, USA). The dry gelatin obtained was ground before being added to surimi.

Surimi preparation

Surimi was prepared using dark-fleshed sardine fish according to the method described by Huda *et al.* (2013b). The head, viscera, and scales of sardines were removed, and the bodies were washed using chilled water. The bones were deboned using a fish bone separator, and the flesh was collected from the perforation drums. The flesh was minced and washed two times using chilled water at a ratio of one part meat to three parts water for 2 min and then allowed to settle for 5 min. The water layer was removed and the residue was filtered using a commercial sieve. Cotton cloth was used to remove the access water in the washed flesh using a hand press machine. Lastly, the raw surimi was mixed with 3% sucrose, 3% sorbitol, and 0.3% sodium triphosphate using a silent cutter. The surimi was packaged and frozen rapidly using a blast freezer before being stored at -20°C or below.

Surimi gel preparation

Sardine surimi was treated with four different types of duck feet gelatin: SHCl: surimi containing gelatin treated with hydrochloric acid; SAa: surimi containing gelatin treated with acetic acid; SLa: surimi containing gelatin

treated with lactic acid; and SCa: surimi containing gelatin treated with citric acid. Surimi without the addition of gelatin was used as the control. Surimi gel was prepared by mixing 3% duck feet gelatin, 2% salt, and 95% surimi for 2 min using a cutter mixer (Robot Coupe, Model Blixer, 3B, France). The samples were stuffed into 25 mm diameter cellulose casings. The stuffed samples were cooked at 36 °C for 30 min, followed by heating at 90 °C for 10 min in a water bath (Model WB-22, Korea). Surimi gels were cooled in ice water for 30 min and stored in a chiller overnight prior to analysis.

Determination of cooking yield and expressible moisture

Cooking yield and expressible moisture (EM) were measured according to Huda *et al.* (2010) and Rawdkuen *et al.* (2007), respectively. Cooking yield is the percentage of cooked gel weight compared to the original weight before cooking. It was calculated as follows:

$$\text{Cooking yield (\%)} = \frac{\text{Cooked surimi gel}}{\text{Uncooked surimi gel}} \times 100$$

To measure EM, gel samples were cut into a thickness of 5 mm, weighed, and placed between two Whatman Filter No. 4 filter papers. A 5 kg standard weight was placed on top of the sample and held there for 2 min, after which the sample was weighed. EM was calculated as follows:

$$\text{EM (\%)} = \frac{x-y}{x} \times 100$$

where, x is the weight of the pre-pressed sample (g) and y is the weight of the pressed sample (g).

Texture analyses

Texture analyses included the folding test, texture profile analysis (TPA), and gel strength measurement. For the folding test (Lanier, 1992), a 3 mm thick slice of surimi gel was cut, held between the thumb and forefinger, and folded slowly to observe gel strength for qualitative assessment. The result was graded as follows: 1 = breaks by finger pressure, 2 = cracks immediately when folded in half, 3 = cracks gradually when folded in half, 4 = no cracks showing after folded in half, and 5 = no cracks showing after folding twice.

TPA was conducted using a Texture Analyzer TA-XT2 (Stable Micro Systems, Godalming, UK) with a compression platen (SMS P/75) on a heavy duty platform. Surimi gels were cut into 25 mm thick slices, and a slice was tested according to the method of Huda *et al.* (2013b) with the following settings: load cell of 30 kg and trigger force of 5 g for 2 seconds with pre-test speed, test speed, and post-test speed of 1.0 mm/sec.

To measure gel strength based on quantitative assessment, a 25 mm thick slice of surimi gel was placed on the platform and penetrated by a spherical probe (P/0.25s). The penetration force (g) and distance of penetration (mm) were used to calculate gel strength (g.mm). The load cell used was 30 kg, the trigger force was 5 g, and pre-test speed and post-test speed were 1 mm/sec.

Colour analysis

L^* (lightness-darkness), a^* (redness-greenness), and b^* (yellowness-blueness) values of surimi gels were measured using a Minolta model CM-3500d spectrophotometer (Kyoto, Japan). The whiteness value was determined using the following equation from Lanier (1992):

$$\text{Whiteness} = 100 - ([100 - L^*]^2 + a^{*2} + b^{*2})^{1/2}$$

Statistical analyses

Statistical Package for the Social Sciences software (SPSS 17.0 for Windows, SPSS Inc, Chicago, IL, USA) was used to conduct one-way analysis of variance to compare experimental results. Duncan tests were used to determine the significance different ($p < 0.05$) among the samples.

RESULTS AND DISCUSSION

Table 1 shows the effect of adding duck feet gelatin on cooking yield and EM of surimi gels. The cooking yield of control surimi gel was significantly ($p < 0.05$) lower than those of the treated gels, as its cooking yield was 94.84% compared to 97.05% for SLa, 97.25% for SHCl, 98.24% for SAa, and 98.66% for SCa. These results are similar to those reported by Huda *et al.* (2013b) and Santana *et al.* (2013), which showed that the addition of hydrocolloid leads to higher cooking yield. According to Pietrasik and Li-Chan (2002), cooking loss is used by the meat industry to evaluate the characteristic of products containing non-meat ingredients during the cooking process. Lower cooking loss in processed meat products due to minimization of weight loss is a characteristic value in the meat processing industry (Pereira *et al.*, 2011), and good quality products typically have high cooking yield.

The EM of surimi gels containing the different duck feet gelatins was significantly lower than that of the control ($p > 0.05$), with values of 2.79%, 3.30%, 6.21%, 11.47% for SCa, SAa, SLa, and SHCl, respectively, compared to 19.70% for the control. Schilling *et al.* (2003) and Huda *et al.* (2013b) also reported that the addition of collagen resulted in lower EM compared to untreated controls. Expressible moisture is related to water holding capacity (WHC), whereby high EM indicates poor WHC (Chaijan *et al.*, 2004). In this study, duck feet gelatin significantly modified the EM of the surimi gels by increasing their myofibrillar protein-protein interactions (Hernández-Briones *et al.*, 2009). Thus, duck feet gelatin can reduce the water loss in surimi gels.

Table 1 Cooking yield and expressible moisture of surimi gels containing duck feet gelatin

Samples	Control	SHCl	SAa	SLa	SCa
Cooking Yield (%)	94.84 ± 0.19 ^a	97.25 ± 0.46 ^b	98.24 ± 0.11 ^c	97.05 ± 0.03 ^b	98.66 ± 0.33 ^c
Expressible moisture (%)	19.70 ± 0.44 ^e	11.47 ± 0.05 ^d	3.30 ± 0.03 ^b	6.21 ± 0.30 ^c	2.79 ± 0.13 ^a

*SHCl = surimi containing duck feet gelatin treated with hydrochloric acid; SAa = surimi containing duck feet gelatin treated with acetic acid; SLa = surimi containing duck feet gelatin treated with lactic acid; SCa = surimi containing duck feet gelatin treated with citric acid.

^{a,b,c} Values are means of triplicate samples with ± standard deviation. Different letters in the same row indicate significant differences ($p < 0.05$).

Table 2 presents the results of the folding test, gel strength measurement, and TPA of the different surimi gels. The folding test score for SHCl, SAa, and SCa was 4 and that of SLa was 3, whereas the score for the control was 1. Thus, compared to the control, all duck feet gelatin-containing surimi gels performed better on the folding test. Lanier (1992) stated that the folding test can be used to differentiate gel cohesiveness, and Nowsad *et al.* (2000) described the folding test as a simple and quick method to determine the quality of gel springiness. However, it does not represent the entire texture profile of samples, as the folding test lacks the sensitivity to distinguish the functional properties of surimi.

Values for hardness, cohesiveness, springiness, and chewiness of sardine surimi containing all four types of duck feed gelatin were significantly higher than those of the control (Table 2). No significant difference in hardness was detected between SHCl and SLa ($p > 0.05$), but SCa had the significantly highest value. Pérez-Mateos and Montero (2000) reported that fish gels containing hydrocolloids were harder than samples without hydrocolloid. No significant difference in cohesiveness between SHCl and SLa was found. Nopianti *et al.* (2012) noted that a cohesiveness value close to 1 indicates sample recovery after the first compression. Springiness of surimi containing the different duck feet gelatins ranged from 0.85 to 0.88 mm, and the SAa sample had the highest springiness. The type of raw fish meat and the conditions during preparation of surimi gel can affect springiness (Chung *et al.*, 2010). Chewiness refers to the energy required to chew surimi until it is ready to be swallowed. SCa had the highest chewiness value, followed by SAa, SHCl, and SLa. Nopianti *et al.* (2012) also reported that chewiness is complementary to hardness, and in the current study all duck feet gelatin treated gels had high values of chewiness and hardness.

Table 2 Results of texture analyses of surimi gels containing duck feet gelatin

Samples	Control	SHCl	SAA	SLa	SCa
Folding test	1.00 ± 0.00 ^a	4.00 ± 0.00 ^c	4.00 ± 0.00 ^c	3.00 ± 0.00 ^b	4.00 ± 0.00 ^c
Gel strength (g.mm)	1857.43 ± 27.43 ^a	6655.57 ± 397.92 ^b	6680.52 ± 50.79 ^b	6928.21 ± 307.46 ^{bc}	7290.00 ± 350.69 ^c
Hardness (g)	1103.69 ± 4.71 ^a	2579.86 ± 36.87 ^b	5897.08 ± 313.81 ^c	2713.48 ± 41.79 ^b	6532.18 ± 433.85 ^d
Texture Profile Analysis:					
Cohesiveness (ratio)	0.20 ± 0.00 ^a	0.62 ± 0.01 ^d	0.27 ± 0.01 ^b	0.60 ± 0.02 ^{cd}	0.57 ± 0.05 ^c
Springiness (mm)	0.59 ± 0.01 ^a	0.86 ± 0.00 ^b	0.88 ± 0.02 ^c	0.86 ± 0.01 ^b	0.85 ± 0.01 ^b
Chewiness (g.mm)	129.45 ± 3.03 ^a	1393.02 ± 33.33 ^{bc}	1417.46 ± 156.24 ^{bc}	1376.43 ± 15.76 ^b	1518.16 ± 4.40 ^d

*SHCl = surimi containing duck feet gelatin treated with hydrochloric acid; SAA = surimi containing duck feet gelatin treated with acetic acid; SLa = surimi containing duck feet gelatin treated with lactic acid; SCa = surimi containing duck feet gelatin treated with citric acid.

^{a,b,c} Values are means of triplicate samples ± standard deviation. Different letters in the same row indicate significant differences ($p < 0.05$).

Gel strength is considered to be the most important parameter for determining surimi quality (Ramadhan *et al.*, 2012). In this study, a significant difference ($p < 0.05$) in gel strength was detected between the control surimi gel and surimi gels containing duck feet gelatin (Table 2). However, no significant difference ($p > 0.05$) in gel strength was found between SHCl and SAA, SAA and SLa, and SLa and SCa. High gel strength of surimi gel is due to hydrogen bonds, disulfide bonds, salt linkages, and hydrophobic interactions that play roles in building a network structure during gelation (Sen, 2005).

Table 3 Colour of surimi gels containing duck feet gelatin

Samples	Control	SHCl	SAA	SLa	SCa
L*	58.25 ± 0.01 ^a	59.88 ± 0.05 ^b	60.48 ± 0.01 ^c	61.36 ± 0.04 ^d	62.80 ± 0.05 ^e
a*	-0.86 ± 0.01 ^a	-0.46 ± 0.01 ^c	-0.40 ± 0.01 ^d	-0.18 ± 0.03 ^b	-0.49 ± 0.23 ^e
b*	12.16 ± 0.02 ^a	13.08 ± 0.02 ^b	13.78 ± 0.02 ^d	13.34 ± 0.00 ^c	15.46 ± 0.08 ^e
Whiteness	56.51 ± 0.01 ^a	57.79 ± 0.04 ^b	58.14 ± 0.01 ^c	59.12 ± 0.04 ^d	59.71 ± 0.07 ^e

*SHCl = surimi containing duck feet gelatin treated with hydrochloric acid; SAA = surimi containing duck feet gelatin treated with acetic acid; SLa = surimi containing duck feet gelatin treated with lactic acid; SCa = surimi containing duck feet gelatin treated with citric acid.

^{a,b,c} Values are means of triplicate samples ± standard deviation. Different letters in the same row indicate significant differences ($p < 0.05$).

Table 3 shows the colour data for the surimi gels. Huda *et al.* (2013b) reported similar values for sardine surimi containing duck feet collagen, with L*, a*, and b* values of 63.60, -0.83, and 11.53, respectively. The similarity of results was not surprising because gelatin is the derivative of collagen. Yellowness (b*) was affected by colour characteristics of duck feet gelatin. Whiteness of the control gel and gels containing the different types of duck feet gelatin differed significantly from one another. Whiteness is another quality characteristic of surimi gels (Kaewudom *et al.*, 2012), but it does not necessarily reflect their functional value. The type and amount of additives incorporated have been reported to affect the whiteness value of surimi gels (Benjakul *et al.*, 2001).

CONCLUSION

The addition of different duck feet gelatins into sardine surimi significantly improved the texture properties (folding, gel strength, and texture profile), cooking yield, and EM of surimi gels. Although the addition of SCa yielded the best quality values in term of texture properties, the quality of sardine surimi of all four types of acid-treated duck feet gelatin are significantly ($p < 0.05$) better than control sample. Thus, duck feet gelatin can be a useful protein additive in sardine surimi.

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