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Short communication

Improving Physicochemical Properties of Minced Fish by Adding Quail Bone Gelatin

Fathin Shahira Samsudin[1], Nuraliah Aminal'lah[1], Ahmad Syazni Kamarudin[2], Nurul Huda[1,3]*

[1]School of Food Industry, [2]School of Animal Science, Faculty of Bioresources and Food Industry, Universiti Sultan Zainal Abidin, Besut Campus,22200, Terengganu, Malaysia.
[3]Institute for Community (Health) Development, Universiti Sultan Zainal Abidin, Gong Badak Campus 21300, Terengganu, Malaysia.
**Corresponding author E-mail: nhuda@unisza.edu.my*

Abstract

The objective of this study was to compare the physicochemical properties (cooking yield, folding test, gel strength, expressible moisture, texture profile analysis, and color) of minced fish containing quail bone gelatin (QBG), commercial bovine gelatin (CBG), or commercial fish gelatin (CFG). QBG was prepared using two acid pretreaments: hydrochloric acid (QBGHCl) and citric acid (QBGc.a). The cooking yield of minced fish gels improved from 94.23% to 96.17–98.48% by the addition of gelatin. Addition of QBGHCl, QBGc.a, CBG, and CFG improved the folding test result from 1.00 to 2.00, reduced expressible moisture from 37.90% to 29.59, 30.19, 27.81, and 36.73%, respectively, and improved gel strength from 69.42 g.cm to 92.17, 96.5, 155.30, and 99.73 g.cm, respectively. Addition of gelatin also increased the hardness and decreased the whiteness of fish minced gels. Thus, the addition of QBG has potential as an alternative gelatin source for improving the physicochemical properties of minced fish.

Keywords: *Minced fish, quail bone gelatin, physicochemical properties, commercial bovine gelatin, commercial fish gelatin*.

1. Introduction

Minced fish primarily is produced from white-muscled fish species with desirable odor, light color, and good gel-forming characteristics [1]. The production of minced fish is a process by which fishery by-products and low-value fish species can be used to provide a source of protein for human consumption. Minced fish manufactured in a hygienic manner has the same quality as the raw material. When good manufacturing practices are followed and high-quality fish are used, the product is boneless, has no smell or pigments, and is suitable for use as an ingredient in other food products. Minced fish can be made into fish flour, fish cakes, fish fingers, surimi, and kamaboko [2]. Gelatin is commonly added to foods to alter their properties. It is a colorless, brittle, flavorless protein that is derived from animal skin, bone, hide, or cartilage. It can be used as a food additive after being subjected to pre-treatment by acid or alkaline hydrolysis. Gelatin has thermo-reversible gel properties and therefore can change its form depending on temperature [3]. Gelatin is used in many bakery products as a thickening agent (E441), emulsifier, binder, and nutrient. Gelatin can be produced from various sources. Although mammals such as pigs and cows are the traditional sources of gelatin used in food processing, health and religious concerns have led researchers to search for alternative sources. Today, gelatins from marine and poultry sources also are commonly used.

The effects of adding alternative sources of gelatin to surimi have been studied previously [3; 4; 5]. However, limited studies of the effects of adding quail bone gelatin (QBG) to minced fish have been conducted. Thus, the objective of this study was to evaluate the effects of the addition of QBG on the physicochemical properties of minced fish gels.

2. Materials and Methods

2.1. Preparation of Quail Bone Gelatin

Quails were purchased from the quail farm at Kemaman, Terengganu and bred by an animal science student at the Universiti Sultan Zainal Abidin Besut campus. After 35 days of maturation, quails were slaughtered, and the flesh and bones were separated to harvest the meat and use the bones for gelatin extraction. Commercial bovine gelatin (CBG) was purchased from Halagel (M) Sdn Bhd (Sungai Petani, Kedah Darul Aman), and commercial fish gelatin (CFG) was obtained from Sigma-Aldrich. CBG and CFG were used for comparison to QBG.

QBG was produced using 0.1 M hydrochloric acid (QBGHCl) or 0.1 M citric acid (QBGc.a). Following methods described by Dunn [6], the quail bones were cut and cleaned prior to the extraction process. The sample then was boiled in water at 100˚C for 40 min to remove skin, fat, and cuticles. The cleaned bones were dried at 50ºC for 18 h [7]. To extract the gelatin, the bones were soaked in the acid solution at the ratio of 1:10 (w/v) for 24 h at 7ºC per batch. The sample then was neutralized for 4 h with flowing tap water until the pH reached 5 [4]. The sample was transferred to a beaker and placed in a water bath at a ratio of 1:2 (w/w) for 2 h at 75ºC. The sample then was filtered using Whatman No. 4 filter paper to obtain the filtrate [3]. Finally, gelatin powder was acquired by freeze drying the sample (Christ Alpha 1-4 LDplus benchtop freeze dryer) at –40˚C.

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2.2. Preparation of Fish Gels

Fish gels were prepared following the method described by Nurkhoeriyati [8]. Frozen minced fish was purchased from Kuala Besut Terengganu. The fish was thawed at 4°C overnight. The minced fish (84%) was mixed with 3% salt, 2% gelatin (QBG, CBG, or CFG), and 11% cold water. The ingredients were mixed for 2 min using a cutter mixer (Robot Coupe, Model Blixer, 3B, France) and stuffed into 2.5 cm diameter artifical casings. The uncooked fish gels were weighed prior to heating in a water bath for 30 min in 36°C followed by cooking in 90°C water for 10 min. The cooked fish gels were immediately cooled in ice water for 30 min before analysis.

2.3. Cooking Yield

Cooking yield was calculated after the fish gel was cooked [9]. The fish gels were blotted dry with paper towels before being weighed. The percentage of cooking yield was calculated by dividing the weight of the cooked fish gel by the original weight before cooking.

2.4. Expressible Moisture (EM)

EM analysis followed the method described by Benjakul et al. [10]. The fish gels were cut into 5 mm thick pieces and weighed. A sample then was placed between two pieces of Whatman filter paper for 2 min with a 5 kg weight sitting on the top piece of filter paper. After 2 min the gel was weighed again.

2.5. Folding Test

The folding test was conducted to determined the grade or quality of the fish gel based on the fold scale. The fish gels were cut into 3 mm thick pieces. The slices were folded according to the procedure described by Lanier [11] and graded as follows: 5 = no cracks after folding twice, 4 = no cracks showing after folding in half, 3 = cracks gradually when folded in half, 2 = cracks immediately when folded in half, 1 = breaks by finger pressure).

2.6. Gel Strength

Gel strength was measured using a texture analyser (TA.XT plus, Stable Micro Systems) as described by Benjakul et al. [10]. The fish gels were cut into 2.5 cm long cylindrical pieces. At room temperature, the sample was pressed using a P/0.25S probe at a constant speed of 1 mm/s at 15 mm distance. The pre-test and post-test speed was 1 mm/s with 5 g of trigger force. The load capacity of the texture analyzer was 30 kg, and the return distance was 35 mm. Gel strength was determined based on the breaking force and deformation of the product as follows:
Gel strength = Breaking force x Deformation

2.7. Texture Profile Analysis (TPA)

A TA.HD plus texture analyser (Stable Micro Systems) equipped with compression platen (SMS P/75) with a load cell of 30 kg was used to measure the textural characteristics of the gels [12]. The settings of the texture analyzer were as follows: 1.0 mm/sec, speed; 1.0 mm/sec, test speed; 1.0 mm/sec, post-test speed; 15 mm, distance; 2 sec, time before second compression; and 5 g trigger force. The parameters measured were hardness (g), cohesiveness, springiness (mm), gumminess (g), and chewiness (g. mm).

2.8. Color Measurement

The color of the fish gels was analyzed using a Chroma Meter CR-400 (Minolta, Tokyo, Japan). The samples were cut into 4 cm lengths, and the color was observed as L* (lightness), a* (redness), and b* (yellowness). The whiteness value was obtained from the following formula [11]:

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

2.9. Statistical Analysis

The data were analyzed using one way analysis of variance followed by Tukey's test for mean comparison. The Statistical Package for Social Science version 20 (SPSS inc., Chicago, IL, USA) was used to conduct all analyses. Significance was defined at $p < 0.05$.

3. Results and Discussion

3.1. Cooking Yield, Expressible Moisture and Folding Test

Table 1 shows the cooking yield, EM, and folding test results of fish gels containing QBGHCl, QBGc.a, CBG, and CFG as well as the control. With the exception of the QBGc.a sample, the cooking yield of the fish gels containing gelatin was significantly higher ($p < 0.05$) than that of the control samples. The cooking yield of the QBGc.a sample was higher than that of the control, but the difference was not statistically significant. Increasing the cooking yield is desirable because it decreases the cooking loss of the product. Lower cooking loss also improves the water binding and gelling ability [13] by the addition of gelatin. The ability of meat to retain fat and water during the heating process is associated with the swelling of meat [14]. Santana et al. [15] also reported that the addition of hydrocolloids increases the cooking yield of meat products.

Table 1: Cooking yield, EM, and folding test of fish gels with and without gelatin.

Samples	Control	QBGHCl	QBGc.a	CBG	CFG
Cooking yield (%)	94.23±1.62^{b}	98.42±1.89^{a}	96.17±1.85^{ab}	98.48±0.62^{a}	97.78±1.87^{a}
Expressible Moisture (%)	37.9±2.00^{a}	29.59±4.74^{bc}	30.19±2.22^{bc}	27.81±2.29^{c}	36.73±7.05^{ab}
Folding Test	1.00±0.00^{b}	2.00±0.00^{a}	2.00±0.00^{a}	2.00±0.00^{a}	2.00±0.00^{a}

$^{a.b.c}$ Different letters in the same row indicate significant difference at $p < 0.05$. Values are means of triplicate measurements ± standard deviation. QBGHCl = fish gels containing quail bone gelatin treated with hydrochloric acid; QBGc.a = fish gels containing quail bone gelatin treated with citric acid; CBG = fish gels containing commercial bovine gelatin; and CFG = fish gels containing commercial fish gelatin.

EM was lower in gels containing gelatin compared to the control, and the difference was statistically significant ($p < 0.05$) for QBGHCl, QBGc.a, and CBG. This result shows that the presence of gelatin allowed the fish gels to hold water more effectively. Nurkhoeriyati et al. [8] reported that poor gel networks with low protein integrity were unable to trap and hold water, which led to high EM values.

The fish gels containing gelatin all had a folding test grade of 2.0, whereas the value was 1.0 for the control. This result shows that the addition of gelatin to minced fish significantly ($p < 0.05$) increased the gel strength of fish gels and improved the quality of low minced fish. Santana et al. [15] reported that folding test related with the myofibrilla protein in fish gels. The score of

folding test also influence by the freshness of meat, meat species, ingredients used and storage method [16].

3.2. Gel Strength and Texture Profile Analysis (TPA)

Table 2 shows the gel strength and texture profile analysis results of fish gels with and without the addition of gelatin. Gel strength of gels containing gelatin was significantly higher ($p < 0.05$) than that of the control. Fish gels containing hydrocolloids are harder than those without hydrocolloids. Ensoy et al. [17] reported that increased amounts of myofibrillar protein and decreased amounts of sarcoplasmic protein are associated with increased gel strength. Benjakul et al. [18] also reported that high gel strength in gels containing gelatin is due to hydrogen bonds, disulphide bonds, salt linkages, and hydrophobic interactions, which build up the network structure during gelation. Thus, the addition of gelatin improved the gel strength. The low gel strength of the control was caused by weak linkage structure or denaturation of actomyosin and myosin [19].

Table 2: Gel strength and TPA results.

Samples	Control	QBGHCl	QBGc.a	CBG	CFG
Gel strength (g.cm)	69.42±2.86^{c}	92.17±14.46^{b}	96.5±8.99^{b}	155.30±14.98^{a}	96.04±12.74^{b}
Hardness (g)	214.26±39.24^{c}	386.31±78.83^{b}	381.84±30.45^{b}	546.93±110.09^{a}	336.70±34.16^{b}
Cohesiveness (ratio)	0.20±0.01^{b}	0.19±0.05^{ab}	0.15±0.00^{c}	0.24±0.04^{a}	0.18±0.01^{bc}
Springiness (mm)	0.62±0.07^{ab}	0.43±0.06^{b}	0.50±0.06^{b}	0.72±0.11^{a}	0.55±0.07^{b}
Gumminess (g)	41.56±4.50^{b}	71.70±16.30^{b}	55.96±4.35^{b}	132.45±34.37^{a}	59.10±6.81^{b}
Chewiness (g.mm)	25.71±3.63^{b}	31.10±11.26^{b}	27.73±3.57^{b}	97.94±36.33^{a}	32.22±5.62^{b}

^{a,b,c} Different letters in the same column indicate significant difference at $p < 0.05$. Values are means of triplicate measurements ± standard deviation. QBGHCl = fish gels containing quail bone gelatin treated with hydrochloric acid; QBGc.a = fish gels containing quail bone gelatin treated with citric acid; CBG = fish gels containing commercial bovine gelatin; and CFG = fish gels containing commercial fish gelatin.

TPA revealed that the CBG gel had the highest hardness value, which was significantly higher ($p < 0.05$) than those of the CFG, QBGHCl, QBGc.a, and control gels in descending order. The quantity of gelatin added affects the hardness of fish gels because it impacts the ability to entrap water [20].

Numerous factors can affect the textural properties of gels. For example, Uresti et al. [21] reported that heating fish gels at 90˚C affected the myosin content, which is a component of myofibrillar protein that is vital for gelling capacity. Ramadhan et al. [22] found that adding salt and changing heating temperature during gel preparation also affected the textural properties. Nopianti et al. [23] reported that the chewiness value increased as the hardness increased.

3.3. Color of Fish Gel

Table 3 shows the color of fish gels with and without the addition of gelatin. The L* and whiteness values of the gels containing gelatin were significantly lower ($p < 0.05$) than those of the control. Kaewudom and Benjakul [24] reported that the lightness of fish gels decreases with the addition of gelatin, and Ahmad and Benjakul [25] found that a longer extraction time decreases the lightness of the gelatin due to the Maillard reaction. Whiteness is another quality index for the physical appearance of fish gels [26] although Norpianti et al. [23] reported that whiteness does not affect their functional values.

The redness and yellowness values of the fish gels were affected to a lesser degree by the addition of gelatin [20]. Changes in a* and b* values may be related to protelysis of proteins that are responsible for the color of meat [21].

Table 3: Color of fish gel

Samples	L*	a*	b*	Whiteness
Control	63.03±0.38^{a}	-0.24±0.43^{b}	11.64±0.03^{ab}	61.78±0.66^{a}
CBG	58.25±1.94^{b}	0.09±0.05^{ab}	11.65±0.38^{ab}	56.65±1.81^{b}
CFG	57.98±1.65^{b}	-0.18±0.07^{b}	11.70±0.20^{a}	56.38±1.54^{b}
QBGc.a	54.48±1.0^{c}	0.46±0.18^{a}	11.12±0.58^{b}	53.14±1.00^{b}
QBGHCl	56.03±2.16^{b}	0.45±0.05^{a}	11.15±0.41^{b}	54.63±2.00^{b}

^{a,b,c} Different letters in the same column indicate significant difference at $p < 0.05$. Values are means of triplicate measurements ± standard deviation. QBGHCl = fish gels containing quail bone gelatin treated with hydrochloric acid; QBGc.a = fish gels containing quail bone gelatin treated with citric acid; CBG = fish gels containing commercial bovine gelatin; and CFG = fish gels containing commercial fish gelatin.

4. Conclusion

The addition of QBG to minced fish improved the textural properties of fish gels in term of cooking yield, folding, EM, gel strength, and texture profile. The quality of fish gels containing QBG was comparable to that of gels containing CBG and CFG. Thus, QBG is a potential alternative gelatin source for improving the physicochemical properties of minced fish.

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