J. Agrobiotech. **Vol. 9** (1S), 2018, p. 92-101.

ISSN 1985-5133 (Press)
ISSN 2180-1983 (Online)

Physicochemical Properties of Quail Bone Gelatin Extract with Hydrochloric Acid and Citric Acid

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Keywords:
Physicochemical properties
Gelatin
Bloom strength
FTIR
Melting temperature

ABSTRACT

Gelatin is a translucent, colorless and flavorless food that was derived from hydrolysis of collagen that was found in animal skin, bone and connective tissue of animals such as domestic cattle, pig, poultry and fish. The objective of the present study is to extract gelatin from quail bone by using acid pretreatment method which is hydrochloric acid (HCl) and citric acid ($C_6H_8O_7$) and to determine the physicochemical properties of quail bone gelatin. The quail bone gelatin (QBG) was compared with commercial bovine gelatin (CBG) and commercial fish gelatin (CFG). Chemical composition (protein, moisture and ash), bloom strength, pH, color, melting temperature and Fourier Transform Infrared Spectroscopy (FTIR) were evaluated. The most important parameter to determine the quality of gelatin is bloom strength. QBG extracted with hydrochloric acid (QBGHCl) has the highest (165.36 g) value followed by citric acid (QBGc.a) which was 149.48 g, while CBG and CFG have bloom value 136.28 g and 91.69 g respectively. There was no significant difference ($p>0.05$) between QBGc.a and CBG but there was significant difference ($p<0.05$) between QBGHCl and CFG. The pH and melting temperature value has range value between 4.84 to 5.46 and 29.34˚C to 38.69˚C. QBGHCl and QBGc.a possesed a similar band (Amide A, Amide B, Amide I, II and III) with CBG and CFG for FTIR. Overall, the physicochemical properties of QBGHCl and QBGc.a has similar quality to CBG which have better quality than CFG. The result has been proven that QBG have a good quality of gelatin, therefore it can be an alternative to gelatin production in the future.

Keywords: Physicochemical properties, gelatin, bloom strength, FTIR, melting temperature

ABSTRAK

Gelatin adalah telus, tanpa warna dan tidak berperisa yang berasal dari hidrolisis kolagen yang terdapat pada kulit binatang, tulang dan tisu penghubung haiwan seperti lembu, babi, ayam dan ikan. Objektif kajian ini adalah untuk mengekstrak gelatin dari tulang puyuh dengan menggunakan kaedah pra rawatan asid iaitu asid hidroklorik (HCl) dan asid sitrik ($C_6H_8O_7$) dan menentukan ciri-ciri fizikokimia gelatin tulang puyuh. Gelatin tulang puyuh (QBG) dibandingkan dengan gelatin lembu komersial (CBG) dan gelatin ikan komersial (CFG). Komposisi kimia (protein, kelembapan dan abu), kekuatan bloom, pH, warna, suhu lebur dan pemprofilan kimia FTIR telah dikaji. Parameter yang paling penting untuk menentukan kualiti gelatin adalah kekuatan bloom. QBG yang diekstrak dengan asid hidroklorik (QBGHCl) adalah yang tertinggi (165.36 g) diikuti oleh asid sitrik (QBGc.a) iaitu 149.48 g, manakala CBG dan CFG masing-masing mempunyai nilai bloom 136.28 g dan 91.69 g. Tidak terdapat perbezaan yang signifikan ($p>0.05$) antara QBGc.a dan CBG tetapi terdapat perbezaan yang signifikan ($p<0.05$) antara QBGHCl dan CFG. Nilai pH dan suhu lebur adalah di antara 4.84 hingga 5.46 dan 29.34˚C hingga 38.69˚C. QBGHCl dan QBGc.a mempunyai band yang serupa (Amide A, Amide B, Amide I, II dan III) dengan CBG dan CFG untuk FTIR. Keseluruhan, sifat fizikokimia QBGHCl dan QBGc.a mempunyai kualiti yang sama dengan CBG yang mempunyai kualiti yang lebih baik daripada CFG. Hasil kajian telah dibuktikan bahawa QBG mempunyai kualiti gelatin yang baik, oleh itu ia boleh menjadi alternatif kepada pengeluaran gelatin pada masa akan datang.

Kata kunci: Ciri-ciri fizikokimia, gelatin, kekuatan bloom, FTIR, suhu lebur

INTRODUCTION

Gelatin has a very broad application in many industrial fields for example in food industry that can be used to improve stability and consistency of food, as a gelling agent, thickener while for non food industry such as cosmetics, medicals and pharmaceutical, it can be used to produce capsules (Widyasari and Rawdkuen., 2014). The world-wide demand for gelatin has been increased in the mid 1990_s. The global demand of gelatin for food and non-food application has reached 348.9 kilo tons in 2011 where 40% overall production in 2011 was utilized from pig skin and the demand for gelatin is expected to reached 450.7 kilo tons in 2018 based on (Transparency Market Research, 2013). Gomez-Guillen et al. (2011) reported that the most abundant source of gelatin in the

market are made from pig skin (46%), followed by bovine hide (29.4%), pork and cattle bones (23.1%) and other sources various species of fish about 1.5%. Recent years, the demand for non-bovine and non-porcine gelatin has increased due to issues of halal food by Muslims and Vegetarians and Kosher food market, occurence of food and mouth disease (FMD) or spread of mad cow disease (Bovine Spongiform Encephalopathy, BSE) reported by (Karim and Bhat., 2009), and fish gelatin that may affect allergic to consumer (Hamada et al.,2001), caused many researcher to find new gelatin sources such as poultry. As a substitution sources of gelatin, quail bone is one of the suitable sources of gelatin. According to poultry world (2009) state that the demand of quail is increasing year by year at 20 to 25%. Quail is one of the leanest types of poultry and a good source of protein and minerals such as sodium, potassium, and iron (Boni,2011). Thus, this study focused to produce gelatin from poultry which is quail bone by using acid pretreatment and study the physicochemical properties of quail bone gelatin.

MATERIAL AND METHODS

Materials

The quail sample was purchased from quail farm at Kemaman, Terengganu, and was breed by animal science student of Universiti Sultan Zainal Abidin Besut campus. After 35 days of breeding and matured, the quail was slaughtered, afterward, the quail flesh and bone were split for meat quality and gelatin extraction. The extraction of gelatin had only used the bone of the quail. The commercial bovine gelatin (CBG) was purchased from Halagel (M) Sdn Bhd, Sungai Petani, Kedah Darul Aman. While, the commercial fish gelatin was obtained from Sigma-Aldrich (St. Louis, MO, USA). Chemicals and reagents that were used were Hydrochloric acid (J.T Baker, Center Valley, PA), Citric acid (Bendosen, Batu Caves, Selangor), 1000 Kjeltabs Cu/3,5 (Foss Analytical A/S, Hillerod, Denmark), Sodium Hydroxide (Merck, Darmstadt, Germany), Sulfuric acid (Merck, Darmstadt, Germany), Boric acid (HmbG, Eschborn, Germany).

Gelatin Extraction

Gelain extraction was done by following method by Dunn (2003).The quail bone needs to be cut and cleaned. The skin, fat, and cuticles were removed by soaking the sample in the boiling water at 100ºC for 40 minutes. Then, the clean quail bone were dried at 50ºC for 18 hours (Muyonga et al., 2004). Quail bone were soaked into 0.1 M hydrochloric acid (HCl) and 0.1 M citric acid ($C_6H_8O_7$) solution for 24 h at 7ºC per batch at the ratio of 1:10 (w/v). After soaking process, the quail bone were neutralized until the pH reach 5 for 4 hours with flowing tap water (Nik et al., 2015). According to Nazri et al. (2012), after the acidic pretreatment the sample was transferred into a beaker and placed in the water bath for 2 hours at 75ºC with ratio 1:2 (w/w). The filtration process used Whatman filter paper No. 4 to obtain the filtrate (Jamilah and Harvinder, 2002). Then, the gelatin powder was obtained from the freeze drying process (christ Alpha 1-4 LDplus benchtop freeze dryer) at -40˚C.

Yield of Gelatin

Cho et al. (2006), reported that the percentage of the gelatin yield was obtained by measuring the weight of gelatin powder.

$$\text{Yield of gelatin (\%)} = \frac{\mathbf{a\ (g)}}{\mathbf{b\ (g)}} \times 100$$

Where,

a: weight of dried gelatin (in gram)
b: weight of raw quail bone (in gram)

Chemical Composition of Gelatin

The moisture, protein and ash of gelatin were determined according to AOAC (2005).The protein content was determined by Kjeldahl method AOAC (2005) with a protein factor of 5.55 to convert the nitrogen value to gelatin protein.

pH Analysis
See et al. (2010) state that the pH of gel is determined at room temperature (27±1°C) by preparing solution at concentration of 6.67% by mixing 6.67 g of gelatin powder into 100 ml distilled water. The pH of gel was measured using Thermo pH meter (Benchtop pH meter, US).

Determination of Color
The determination of gelatin color by using Chroma Meter CR-400 (Minolta, Japan) by measuring the L*(lightness), a*(+a*, redness/ -a*, greenness) and b*(+b*, yellowness/ -b*, blueness) value (Rammaya et al., 2012). The Chroma Meter were calibrated prior analysis by placing the tip of measuring head flat against the white surface of the Konica Minolta calibration plate. While the whiteness value was determined using equation from Larnier (1992).

Whiteness = $100 - \sqrt{(100 - L*)^2 + a*^2 + b*^2}$

Bloom Strength
Norizah et al. (2013) stated that the bloom strength of gelatin are determined using texture analyser TA.XT plus (stable Micro Systems). 6.67 g of gelatin was mixed with 100 ml distilled water in the bloom jar to produce 6.67% (w/v) gelatin solution. The gelatin solution was swirled and left for 3 hours at room temperature. Next, 60°C of temperature was used to heat the gelatin solution for 20 min or until the gelatin powder dissolved completely. After that, the gelatin was cooled for 15 min at room temperature before keep in a refrigerated for 16-18 hours at 10°C for gel maturation. Finally, the bloom strength (g) of the gel are measured using standard radius cylinder (P / 0.5 R) probe with depth 4 mm/s and load cell of 5 kg.

Melting Temperature
To measure the melting temperature of gelatin, the gelatin sample was prepared at 6.67% (w/v) concentration and kept overnight in chiller. Differential scanning calorimetry (DSC) was used to determine the melting temperature (Norizah et al., 2013).40 µl aluminium hermetically sealed pan was used to enter the 20 mg gelatin gels. The melting rate of the gelatin used was 5–70 ºC for 2ºC/min.

Fourier Transform Infrared Spectroscopy (FTIR)
Gelatin sample was subjected to FTIR analysis using an ATR-FTIR spectrometer, Shimadzu IR-Prestige-21. First, the background was run without the sample followed by placing the gelatin sample on the crystal cell by using spatula and spread them on the crystal until it was covered. The cell was clamped into the mount of the FTIR spectrometer. Automatic signals gained was collected in 16 scans at the resolution 4 cm^{-1} against the background spectrum recorded from the clean empty cell at 25°C and the spectra in range 400 – 4000 cm^{-1} was ratio (Ahmad and Benjakul., 2011).

Statistical Analysis
The data were analyzed using statistical one way analysis of variance (ANOVA) followed by Tukey test for mean comparison of Statistical Package for Social Science version 20 (SPSS inc., Chicago, Illinois, U.S.A). Significant different was define at $p < 0.05$.

RESULTS AND DISCUSSION

Yield and Chemical Composition
The yield and chemical composition of commercial bovine gelatin(CBG), commercial fish gelatin (CFG) and quail bone gelatin treated with hydrochloric acid (QBGHCl) and citric acid (QBGc.a) were shown at Table 1.

There was siginificant difference between QBGHCl and QBGc.a ($p<0.05$). Yield of QBGc.a was higher (1.71%) compared than QBGHCl (1.35%) due to strong acid, HCl. According to Tavakolipour (2011), organic acids such as citric acid are better than HCl because strong acids caused denatured to the collagen protein that will affect the quality of gelatin. Previous study by Liu et al. (2001) stated that chicken feet gelatin extracted using HCl had the lowest yield compared to other acids treatment. Lower yield of gelatin may due to loss of extracting

collagen through leaching during washing in the pretreatment process or during the series of washing steps (Sarbon et al., 2013). It can be confirmed by Schrieber and Gareis (2007) in which raw materials undergoes several washes causes the collagen dissolved in the aqueous phase and resulted in lower yield. Several factors also can affected the percentage of gelatin obtained which were proximate composition, species, age of animals, collagen content and method of extraction (Songchotikunpan et al., 2008).

Table 1 Yield and chemical composition of commercial bovine gelatin, commercial fish gelatin and quail bone gelatin.

Samples	Yield (%)	Protein (%)	Moisture (%)	Ash (%)
CBG	-	87.92±0.82^{a}	11.18±0.14^{b}	1.22±0.34^{b}
CFG	-	89.86±1.81^{a}	11.60±0.17^{ab}	0.40±0.64^{b}
QBGc.a	1.71±0.01^{a}	67.68±1.23^{b}	12.09±0.64^{a}	14.82±2.45^{a}
QBGHCl	1.35±0.01^{b}	68.02±2.68^{b}	15.90±0.01^{a}	14.88±0.02^{a}

$^{a-b}$Means with different superscript letters within the same column are significantly different at $p<0.05$. Value are means of triplicate samples with ± standard deviation. CBG, commercial bovine gelatin; CFG, commercial fish gelatin and QBGc.a, quail bone gelatin treated with citric acid; and QBGHCl, quail bone gelatin treated with hydrochloric acid.

There was significant difference ($p<0.05$) between QBGHCl and QBGc.a with CBG and CFG in which CBG and CFG showed high protein. Previous study reported by Sarbon et al. (2013) indicated that CBG had protein content with value 81.75% which the value was almost close to that found in this study. Gelatin extracted from waste chicken bone was found to have high protein content with value 88.75% (Zhang et al., 2010). Resulted of low protein content was due to the termination of high hydrogen bonds and the opening of coil structure of collagen in excess caused some of the amino acids extracted and separated from the collagen and carried away by washing process (Ulfah, 2008). In the other hand, due to elevated temperature during extraction, the gelatin may be degraded then caused the lower protein content. Previous study by Nazri and Shariffah (2012) showed that the protein content of chicken feet gelatin extracted at 75 °C for 2 hours obtained 67.40 % protein content which is comparable to QBG (67.68 and 68.02 %)in this study.

There were significant differences ($p<0.05$) of moisture content QBGHCl and QBGc.a with CBG (15.90%, 12.09% and 11.18%) respectively. Gelatin Manufacture Institute of America (GMIA) had prescribed the limit of moisture content for edible gelatin within the range less than 15%. Schrieber and Garies (2007) reported that factors that can influenced the moisture content of gelatin was drying time, humidity, storage temperature and type of packaging, moisture content more than 16% can increased the risk of lump formation and microbial growth. Other than that, shelf life of gelatin also can be increased if the moisture content is low and can prevented the gelatin from become sticky (Rahman and Jamalullail., 2012).

The ash content of CBG (1.22%) and CFG (0.40%) have no significant difference ($p>0.05$) but significant difference with QBGHCl (14.88%) and QBGc.a (14.82%). According to GMIA (2013), ash content of gelatin must not exceed 2% for edible gelatin while under Food Act 1983 and Food Regulation 1985 stated that the permitted ash content was not exceeding 3% (Nazri and Shariffah., 2012). Ash content of QBGHCl and QBGc.a was exceeds the prescribed limit due to demineralization process was not conducted. Almeida and Lannes (2013) reported that ash content is among the vital chemical characteristics of gelatin which depends on the type of the materials used in the extraction process. Previous study by Yousefi et al. (2016) stated that the quail feet gelatin extracted using acid treatment contain 2.9% ash.

pH, Bloom strength and Melting temperature

Table 2 showed the pH, bloom strength and melting temperature of commercial bovine gelatin (CBG), commercial fish gelatin (CFG) and quail bone gelatin treated with hydrochloric acid (QBGHCl) and citric acid (QBGc.a). Songchotikunpan et al. (2008) stated that the pH of gelatin can be affected by the type and strength of chemical used for pretreatment. The lower the pH value indicated the higher the concentrationof hydrogen ions in acid solution and Alfaro (2008) registered that the higher pH value of gelatin was because of effectiveness of washing the raw material after chemical treatment before extraction of gelatin. GMIA standard 2013 stated that the pH value using acid pretreatment must within the range 4.5 to 6.5. The pH obtained for CBG, CFG, QBGc.a and QBGHCl were 5.46, 4,84, 5.16 and 4.90 respectively.

Table 2 pH, bloom strength and melting temperature of commercial bovine gelatin, commercial fish gelatin and quail bone gelatin.

samples	pH	Bloom strength(g)	Melting temperature (˚C)
CBG	5.46±0.16[a]	136.28±7.02[a]	38.69±1.58[a]
CFG	4.84±0.07[c]	91.67±19.31[b]	29.34±1.05[c]
QBGc.a	5.16±0.01[b]	149.08±30.53[a]	34.50±0.71[b]
QBGHCl	4.90±0.03[c]	165.36±21.91[a]	36.11±1.10[a]

[a.b.c]Means with different superscript letters within the same column are significantly different at $p<0.05$.Value are means of triplicate samples with ± standard deviation. CBG, commercial bovine gelatin; CFG, commercial fish gelatin and QBGc.a, quail bone gelatin treated with citric acid; and QBGHCl, quail bone gelatin treated with hydrochloric acid.

Bloom strength of CFG (91.67 g) was significantly difference ($p<0.05$) with CBG, QBGHCl and QBGc.a with value 136.28 g, 165.36 g and 149.08 g. The bloom strength or gel strength is the key to measure the quality of gelatin (Cho et al., 2007) in which the higher the bloom value, the stronger the gel strength (Abdullah et al., 2016). In addition, Abdullah et al. (2016) also stated that the bloom or gel strength also influenced by the concentration and molecular weight. High molecular weight will develop high bloom strength due to the well establishes of hydrogen bonds between water molecule and free hydroxyl groups of amino acids. According to Schrieber and Gareis (2007), gelatin can be classified into three groups which were high bloom (200 -300 g), medium bloom (100-200 g) and low bloom (50 -100 g). Thus, high value of bloom strength indicates good quality of gelatin. Other than that, Cheow et al. (2007) stated that the present of higher or lower content of hydroxyproline also will resulted in high or low bloom strength where the gelling effect was due to hydroxyproline content. Bloom strength also related with the melting temperature in which high bloom strength contributed to high melting temperature and gelation point (Almeida et al., 2013).

Mariod and Adam (2013) mention that temperature where the gelatin gel soften known as melting temperature and it is one of the most important physical properties to determine the best quality of gelatin gel. In this study, the melting temperature of CBG, CFG, QBGHCl and QBGc.a were 38.69˚C, 29.34˚C, 36.11˚C and 34.50˚C respectively. The content of proline and hydroxyproline are one of the factors that can affect the melting temperature due to the both amino acids play a role to stabilized the collagen structure (Norziah et al., 2009) in which low hydroxyproline and proline content lead to low melting temperature. According to Choi and Regenstein (2000) stated that mammalian gelatin has higher melting temperature compared to fish gelatin because fish gelatin has lower imino acids proline and hydroxyproline.In addition.Norizah et al. (2013) reported that low melting temperature indicates the structural stability of gelatin is weak.

Color of Gelatin Powder and Gelatin Gel

The color of gelatin powder and gelatin gel of CBG, CFG, QBGc.a and QBGHCl was presented in Table 3. CBG showed no significant difference ($p>0.05$) in L* value but significantly difference in a*, b* and whiteness value compared with QBGc.a. Meanwhile, a* and b* value does not show significant difference ($p>0.05$) for QBGc.a. and QBGHCl but significantly difference for L* and whiteness value. According to Khiari et al (2011), the color of gelatin was influenced by the acid used and their pH in extraction process. Furthermore, Cheow et al. (2007) reported that the raw materials used will affect the color of gelatin but does not affect the functional properties. Previous study by Liu et al.(2001) stated that the longer the soaking time of raw materials in the acidic pretreatment, the higher the value of L* but lower the value of a* while value of b*remains stable. According to Cole (1995), the gelatin derived from bovine hide tend to have darker color compared to gelatin from pig skin because of the presence of pentosidine crosslink collagen. The color of gelatin gel of QBGc.a and QBGHCl does not show significant difference for L*, a*, b* and whiteness value but significant difference with CBG and CFG. Previous study reported by Muyonga et al.(2004) in which the turbidity valueof bone gelatin is higher than gelatin from animal skin and the high value of turbidity was due to imperfect filtering.

Table 3 Color of gelatin powder and gelatin gel for commercial bovine gelatin, commercial fish gelatin and quail bone gelatin

Gelatin Powder	L*	a*	b*	Whiteness
CBG	64.44±3.52^{b}	-0.37±0.23^{b}	27.26±0.82^{a}	55.12±2.34^{b}
CFG	71.58±2.52^{a}	-0.12±0.07^{a}	23.28±1.07^{b}	63.20±1.44^{a}
QBGc.a	62.63±6.32^{b}	-0.72±0.30^{c}	2.95±0.75^{c}	62.49±6.30^{a}
QBGHCl	51.59±6.80^{c}	-0.87±0.96^{c}	6.37±0.90^{c}	51.14±6.69^{b}
Gelatin Gel	L*	a*	b*	Whiteness
CBG	10.85±0.55^{c}	-1.66±0.08^{a}	9.96±0.77^{b}	10.27±0.46^{c}
CFG	14.91±0.38^{b}	-2.57±0.11^{c}	11.45±0.10^{a}	14.10±0.37^{b}
QBGc.a	33.34±1.14^{a}	-2.19±0.02^{b}	4.55±0.32^{c}	33.15±1.14^{a}
QBGHCl	36.13±0.57^{a}	-2.17±0.09^{b}	7.85±1.05^{c}	35.61±0.65^{a}

$^{a.b.c}$Means with different superscript letters within the same column are significantly different at $p<0.05$. Value are means of triplicate samples with ± standard deviation. CBG, commercial bovine gelatin; CFG, commercial fish gelatin and QBGc.a, quail bone gelatin treated with citric acid; and QBGHCl, quail bone gelatin treated with hydrochloric acid.

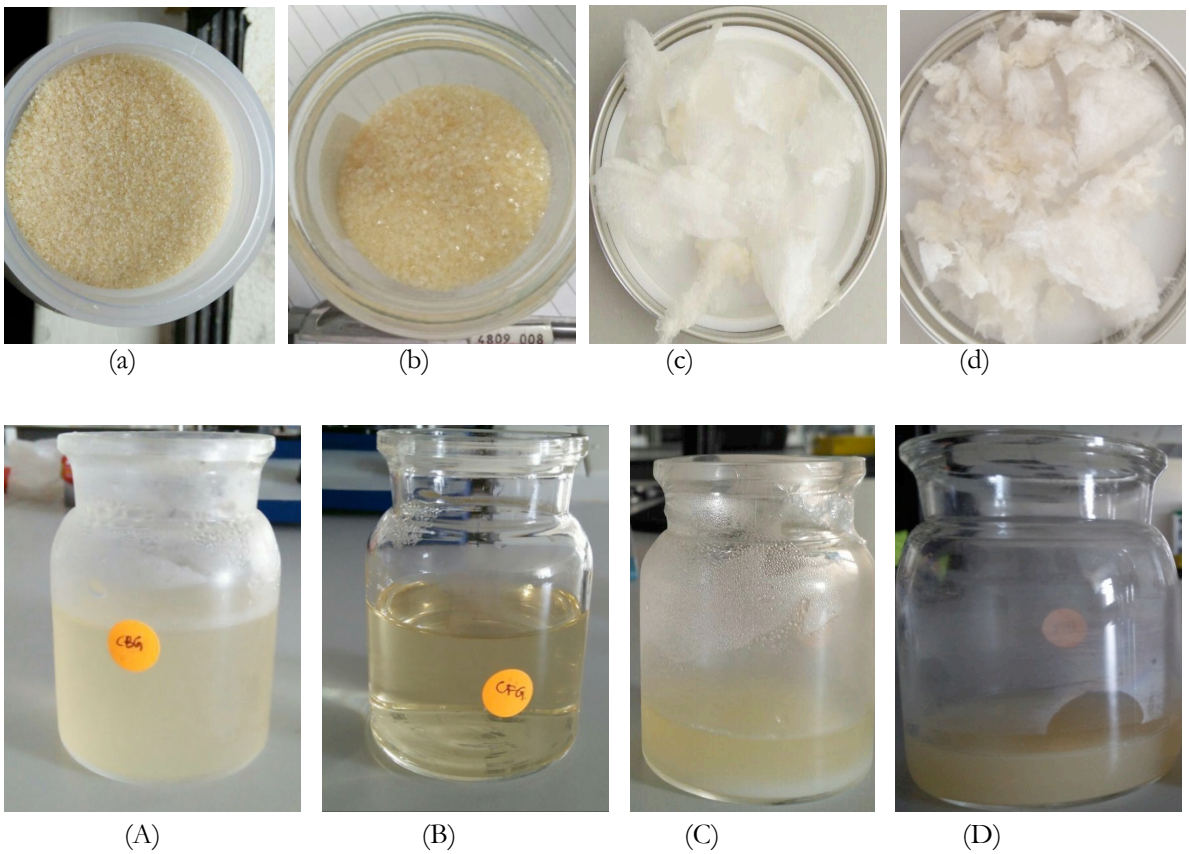

Figure 1 Color of gelatin powder; (a), Commercial bovine gelatin; (b), Commercial fish gelatin; (c), Quail bone gelatin extracted with citric acid; (d), Quail bone gelatin extracted with hydrochloric acid. Color of gelatin gel; (A), Commercial bovine gelatin; (B), Commercial fish gelatin; (C), Quail bone gelatin extracted with citric acid;(D), Quail bone gelatin extracted with hydrochloric acid

Fourier Transform Infrared Spectroscopy (FTIR)

FTIR spectroscopy has been used to monitor the functional groups and secondary structure of gelatin (Muyonga et al., 2004).

Figure 2 showed FTIR-spectroscopy fingerprint of commercial bovine gelatin(CBG), commercial fish gelatin (CFG) and quail bone gelatin treated with hydrochloric acid (QBGHCl) and citric acid (QBGc.a). From the Figure 2, it shows that the amide region is the major peak of all gelatin samples. The FTIR profile of QBGHCl and QBGc.a have similar pattern compared to commercial gelatin with the presence of amide peak. The FTIR spectra of QBGc.a and QBGHCl consits of amide I, amide II, amide III, amide A and amide B which is 1629 cm^{-1} ; 1635 cm^{-1}, 1550 cm^{-1} ; 1546 cm^{-1} , 1238 cm^{-1} ; 1246 cm^{-1} ,3398 cm^{-1} ; 3288 cm^{-1} , and 2931 cm^{-1} ; 2925 cm^{-1} respectively. Meanwhile, FTIR spectra for CBG and CFG were 1616 cm^{-1}; 1635 cm^{-1}, 1514 cm^{-1} ; 1533 cm^{-1}, 1265 cm^{-1} ; 1249 cm^{-1}, 3284 cm^{-1}; 3280 cm^{-1} , and 2953 cm^{-1} ; 2947cm^{-1} respectively. Previous study by Almeida et al. (2012) on FTIR spectra of chicken feet gelatin showed the major peak in amide region and all amide were identified as amide I (1652 cm^{-1}), amide II (1540 cm^{-1}), amide III (1241 cm^{-1}), amide A (3400 cm^{-1}) and amide B (2933 cm^{-1}). Muyonga et al. (2004) and Almeida et al. (2012) reported that amide bands including amide I, II, III, A and B band, which is involved in the triple helical structure of collagen are a result of C=O stretches, N-H bends, CH stretching, N-H stretching and interaction of –NH3 group between peptide chains respectively. Normally, the FTIR spectra of proteins are around 1700, 1500, 1200, 3500, and 2900 cm^{-1} respectively for amide I, II, III, A and B vibration mode. Nasikin et al. (2012), mention that the available amide in FTIR fingerprint showed specific functional groups in different protein samples. In addition, differences in spectral of gelatin samples was due to the secondary structure of gelatin that was affected by acid pre-treatment and extraction time (Ahmad and Benjakul., 2011).

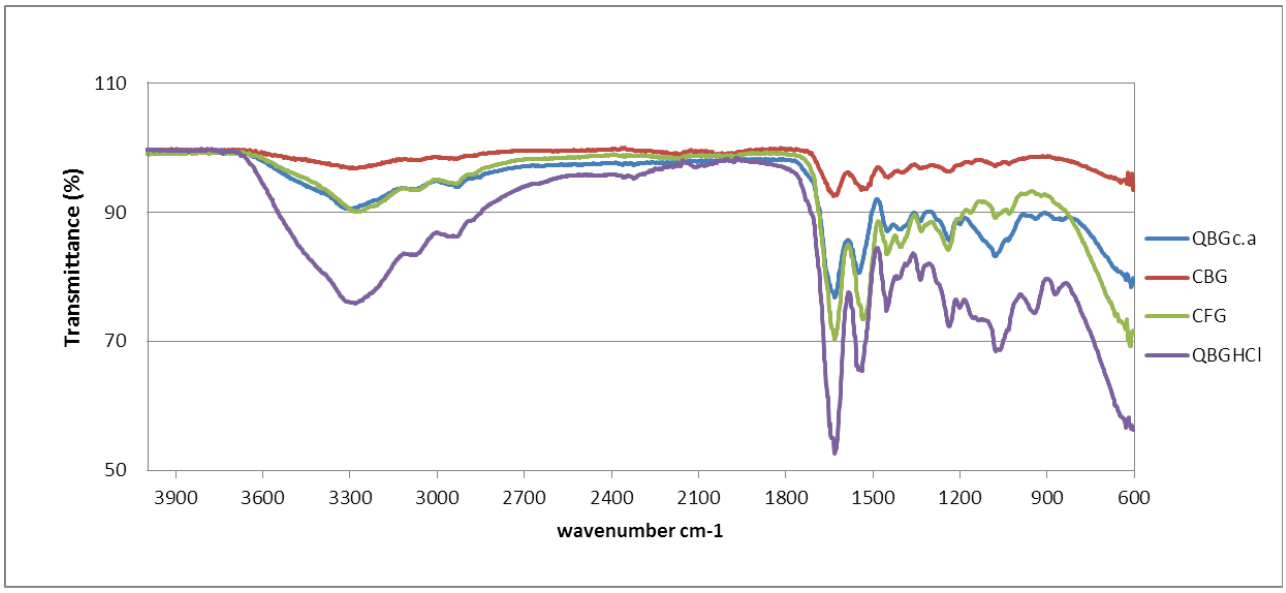

Figure 2 FTIR-spectroscopy fingerprint of quail bone gelatin extract with different acid, commercial bovine gelatin and commercial fish gelatin. QBGc.a, quail bone gelatin extracted with citric acid; QBGHCl, quail bone gelatin extracted with hydrochloric acid; CBG, commercial bovine gelatin; and CFG, commercial fish gelatin.

CONCLUSIONS

Gelatin from quail bone was successfully extracted by using hydrochloric acid and citric acid even though the yield is relatively low. Bloom strength of quail bone gelatin treated with hydrochloric acid and citric acid considered as medium quality of gelatin and comparable with commercial bovine gelatin. Research on physicochemical properties of quail bone gelatin should be continued in the future due to the limitation of data in quail bone gelatin. Further study is required to study the amino acid composition and effect of quail bone gelatin in other gelation-based product. Quail bone gelatin can be alternative sources for the manufacturing of gelatin other than mammalian and marine sources

ACKNOWLEDGEMENTS

The authors acknowledge with gratitude the support provided by Universiti Sultan Zainal Abidin to conduct research in the area Food Science and Technology through research grant UniSZA/2017/DPU/11.

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