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Interfacial properties of gelatin from goat skin as influenced by drying methods

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ABSTRACT

Interfacial properties of spray-dried goat skin gelatin (SDGG) and freeze-dried counterpart (FDGG) were determined, in comparison with commercial bovine gelatin (BG). SDGG had the highest surface hydrophobicity ($p < 0.05$), followed by FDGG and BG, respectively. FDGG became more positively or negatively charged than SDGG at pH below or above pIs (4.83–4.88). Foam expansion and stability of all gelatins increased with increasing concentrations (10–30 g/L) ($p < 0.05$). SDGG had higher foam expansion and stability than FDGG. Emulsion containing SDGG had the higher droplet size (d_{32}, d_{43}) and flocculation factor than that stabilized by FDGG ($p < 0.05$). The former also showed the lower stability as indicated by the higher coalescence index with lower negative charge after 10 d of storage. Thus, drying methods affected both foaming and emulsifying properties of goat skin gelatin.

1. Introduction

Gelatin is the collagenous protein obtained by thermal denaturation or partial hydrolysis of bovine and porcine skins as well as demineralized bones (Mohtar, Perera, & Quek, 2010). Gelatin has many applications in food and non-food industries (Sinthusamran, Benjakul, & Kishimura, 2014). Gelatin has been used as a wetting, foaming and emulsifying agents in food, pharmaceutical, medical and technical applications due to its surface-active properties (Balti et al., 2011). Generally, functional properties of gelatin are governed by several factors, such as raw material, pretreatment and extraction conditions (Benjakul, Kittiphattanabawon, & Regenstein, 2012; Kołodziejska, Kaczorowski, Piotrowska, & Sadowska, 2004; Nagarajan, Benjakul, Prodpran, Songtipya, & Kishimura, 2012; Regenstein & Zhou, 2007). Despite of wide applications, the uses of gelatins are still limited due to the pessimism and strong concerns related with religion (Asher, 1999). Porcine gelatin cannot be used in Kosher and Halal foods, while bovine gelatin is prohibited for Hindus (Kaewruang, Benjakul, Prodpran, & Nalinanon, 2013). Poultry gelatin has been also concerned, due to avian influenza. Thus, gelatin from alternative land animals, especially by-products from goat slaughtering, e.g. skin or bone, can be of choices for consumers. When goats are slaughtered, skin generated as by-product accounts for 6.4–11.6 g/100 g (based on the body weight) (Warmington & Kirton, 1990). Recently, gelatin has been extracted from goat skin after the appropriate alkaline pretreatment is implemented (Mad-Ali, Benjakul, Prodpran, & Maqsood, 2016).

Drying is one of essential processes for gelatin manufacturing. Among all methods, spray drying has been widely applied in the food industry since good quality and low water activity of powder can be gained (Ferrari, Germer, & de Aguirre, 2012). Spray drying is less time-consuming and costly than freeze-drying. Freeze-drying process is 4–5 times more expensive than spray drying (Hammami & René, 1997). Spray drying has been shown to lower undesirable odor from gelatin extracted from fish skin (Sae-leaw, Benjakul, & O'Brien, 2016; Sai-Ut, Benjakul, Sumpavapol, & Kishimura, 2014). Nevertheless, drying conditions influenced the properties of gelatin from sea bass skin, especially gelling properties (Sae-leaw et al., 2016). However, the little information regarding the interfacial properties of goat skin gelatin exists. The objective of the present study was to determine foaming and emulsifying properties of gelatin from goat skin as affected by different drying methods.

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2. Materials and methods

2.1. Chemicals/gelatin

All chemicals were of analytical grade. 1-anilinonaphthalene-8-sulfonic acid (ANS) was purchased from Sigma-Aldrich Chemical Co. (St. Louis, MO, USA). Food grade bovine bone gelatin with the bloom strength of 150–250 g was procured from Halagel (Thailand) Co., Ltd. (Bangkok, Thailand).

2.2. Collection and preparation of goat skins

Skins from Anglo-Nubian goats with the age of approximately 2 years were collected from a local slaughter house in Chana district, Songkhla province, Thailand. Seven kilograms of goat skins were randomly taken from three goats, pooled and used as the composite sample. The skins were packed in polyethylene bag, embedded in the insulated box containing ice (a skin/ice ratio of 1:2, w/w) and transported to the Department of Food Technology, Prince of Songkla University, within 2 h. Upon arrival, the skins were cleaned and washed with running water (26–28 °C). Prepared skins were then cut into small pieces (2.5 × 2.5 cm^2) using knives, placed in polyethylene bags and stored at −20 °C until use. The storage time was not longer than 2 months. Before use, the frozen skins were thawed using a tap water (26–28 °C) for 15 min.

2.3. Pretreatment of goat skins

Prepared skins were pretreated with 0.75 mol/L NaOH solution at a ratio of 1:10 (w/v) at room temperature (25–28 °C). The mixture was stirred manually two times/d. Alkaline solution was removed and replaced by the same volume of freshly prepared solution one time/d for totally 2 d. The skins were drained on the perforated screen.

Alkali-pretreated skins were then mixed with 10 vol of 0.75 mol/L Na_2SO_4 solution and left at room temperature for 24 h. Thereafter, the skins were washed with running water until the pH of wash water became neutral or slightly alkaline. After washing, the obtained skins were soaked in 2 mol/L H_2O_2 solution at a ratio of 1:10 (w/v). The mixture was allowed to stand at 4 °C for 24 h. During soaking, H_2O_2 solution was changed every 12 h. The skin samples were then washed thoroughly three times with 10 vol of tap water. The obtained skins were used for gelatin extraction.

2.4. Extraction of gelatins

Pretreated skins were firstly placed in distilled water (50 °C) with a skin/water ratio of 1:10 (w/v) in a temperature-controlled water bath (W350, Memmert, Schwabach, Germany). The mixture was stirred continuously for 2.5 h at a speed of 150 rpm using an overhead stirrer equipped with a propeller (RW 20. n, IKA-Werke GmbH & CO. KG, Staufen, Germany). The mixture was then filtered using two layers of cheesecloth. The filtrate was further filtered using a Whatman No. 4 filter paper (Whatman International, Ltd., Maidstone, England) with the aid of JEIO Model VE-11 electric aspirator (JEIO TECH, Seoul, Korea).

The resulting filtrate was further mixed with diatomaceous earth (5 g/L). The mixture was stirred using an overhead stirrer at a speed of 100 rpm for 30 min, followed by centrifugation at 8000*g* at 28 °C using a centrifuge model Avanti J-E (Beckman Coulter, Inc., Palo Alto, CA, USA) for 15 min to remove the debris. The supernatant was subsequently mixed with activated carbon (3 g/L). The mixture was stirred at room temperature using an overhead stirrer at a speed of 100 rpm for 30 min. The mixture was then centrifuged at 12,000*g*. The supernatant with 12.5 g/L solid content was collected and subjected to drying.

2.5. Drying of gelatin

Clarified gelatin solution was separated into two portions. The first portion was dried using a spray dryer (LabPlant SD-06 Basic, North Yorkshire, England) equipped with a spry-drying chamber having 500 mm height and 210 mm diameter and a two-liquid-nozzle spray nozzle (0.5 mm in size). A cyclone separator, a hot-air blower, and an exhaust blower were equipped. The gelatin solution was fed by a peristaltic pump at 485 mL/h into the chamber, and atomized by hot air (air velocity of 2 m/s) from the blower in a downward current flow mode, using an inlet temperature of 160 °C, and an atomizing pressure of 2.8 bars. The second portion was freeze-dried using a freeze dryer (CoolSafe 55, ScanLaf A/S, Lynge, Denmark) at −50 °C for 72 h.

The obtained gelatins were transferred into a ziplock bag, placed in a plastic vacuum box and stored at room temperature (25–28 °C) until analyses.

2.6. Analyses

2.6.1. Proximate analysis

Moisture, ash and fat contents of gelatin samples were determined according to the AOAC method (AOAC, 2000). Protein content was measured by the Kjeldahl method (AOAC, 2000) and a nitrogen conversion factor of 5.4 was used for calculation of protein content (Eastoe & Eastoe, 1952). Hydroxyproline content was determined according to the method of Bergman and Loxley (1963).

2.6.2. Determination of protein surface hydrophobicity

Protein surface hydrophobicity was determined by the method of Benjakul, Seymour, Morrissey, and An (1997). Gelatin was dissolved in 10 mmol/L phosphate buffer, pH 6.0, containing 0.6 mmol/L NaCl to obtain a final protein concentration of 5 g/L. The gelatin solution was diluted to 0.125, 0.25, 0.5 and 1 g/L using the same buffer. The diluted gelatin solutions (4 mL) were well mixed with 20 μL of 8 mmol/L 1- anilinonaphthalene-8-sulfonic acid (ANS) in 0.1 mmol/L phosphate buffer, pH 7.0. The relative fluorescence intensity of ANS-protein conjugates was measured using a spectrofluorometer (RF-15001, Shimadzu, Kyoto, Japan) at the excitation wavelength of 374 nm and the emission wavelength of 485 nm. Protein surface hydrophobicity was calculated from initial slopes of plots of relative fluorescence intensity versus protein concentration (g/L) using a linear regression analysis. The initial slope was referred to as S_0ANS.

2.6.3. Determination of ζ-potential

Gelatin samples were dissolved in distilled water at a concentration of 0.5 g/L. The mixtures were stirred at room temperature for 6 h. The ζ-potential of each sample (20 mL) was measured using a zeta potential analyzer (ZetaPALS, Brookhaven Instruments Co., Holtsville, NY, USA). ζ-Potential of samples adjusted to different pHs with 1.0 mol/L nitric acid or 1.0 mol/L KOH using an autotitrator (BIZTU, Brookhaven Instruments Co., Holtsville, New York, USA) was determined. The pI was estimated from pH rendering ζ-potential of zero.

2.6.4. Determination of foaming properties

Foam expansion (FE) and foam stability (FS) of gelatin solutions with different concentrations (10, 20 and 30 g/L) were determined as described by Shahidi, Han, and Synowiecki (1995). Gelatin solutions were transferred into 100 mL cylinders and homogenized at 13,400 rpm using an IKA Labortechnik homogenizer (Selangor, Malaysia) for 1 min at room temperature (25–26 °C). The sample