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Combination effect of high pressure treatment and ethanolic extract from coconut husk on gel properties of sardine surimi

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ABSTRACT

Effects of ethanolic coconut husk extract (ECHE) at various levels (0–0.10 g extract/100 g protein) on gel properties of sardine (*Sardinella albella*) surimi under different gelling conditions including pressurization at 300 MPa, 30 min (HP); and pressurization, followed by heating (90 °C, 20 min) (HP/H) were investigated. At the same level of ECHE, HP/H gel had the higher breaking force ($P < 0.05$) than HP counterpart. The increases in breaking force and water holding capacity were observed as the levels of ECHE were increased up to 0.075 g/100 g for all gels, regardless of gelling processes used ($P < 0.05$). With the addition of 0.075 g/100 g ECHE, breaking force of HP and HP/H were 435 and 577 g, respectively. Lower autolysis of surimi gel was also found in HP/H gel in the presence of ECHE. With addition of ECHE at a concentration of 0.075 g/100 g, HP/H gel had a network with higher connectivity than HP gel and traditional two-step heated gel. Pressurization prior to heating could thus improve quality of sardine surimi gel when ECHE (0.075 g/100 g) was incorporated, in which the breaking force was increased by 69%, compared with that of traditional control gel (without ECHE).

1. Introduction

Coconut husk is a fibrous external portion of the fruit of coconut and is considered as underutilized natural resource (Panyakaew & Fotios, 2011). Various phenolic compounds have been found in coconut husk, namely 4-hydroxybenzoic acid, ferulic acid, tannic acid, and catechin. Lignin precursor such as vanillic acid, ρ-coumaric acid and syringic acid were also identified (Viju, Satheesh, & Vincent, 2013). Phenolic compounds have been known to possess antioxidant (Maqsood, Benjakul, Abushelaibi, & Alam, 2014), antimicrobial and anticancer activities (Lima et al., 2015). Furthermore, phenolic compounds have been demonstrated as protein cross-linking agents, which were able to strengthen the protein gels, especially surimi (Temdee & Benjakul, 2014). Recently, ethanolic coconut husk extract (ECHE) has been reported to induce cross-linking of myofibrils from sardine. It was able to strengthen the gel from sardine surimi prepared by two-step heating (Buamard & Benjakul, 2017a; Buamard, Benjakul, & Konno, 2017). The addition of ECHE up to 0.125 g/g protein had no impact on taste liking score of sardine surimi gel (Buamard & Benjakul, 2015).

Gel-forming properties of myofibrillar proteins are essential for the development of muscle-based product from surimi (Sun & Holley, 2011). Gelling property of surimi depends on several factors including species and freshness of raw materials, additives used, etc. Dark fleshed fish such as sardine and mackerel, which contain high fat and endogenous proteases, yield surimi with poor gel properties (Sriket, 2014). Technologies used for enhancement of gelation, especially for surimi with poor gelling property, have been developed. High pressure processing has been known as a non-thermal processing technology to preserve food products. It has also been employed to modify or improve the functional properties of proteins, particularly gelation (Sun & Holley, 2011).

High pressure has been used to induce gelation of surimi, in which gel with high elasticity was obtained (Angsupanich, Edde, & Ledward, 1999). At the initially pressurizing stage, the hydrophobic interactions of native protein structure are disrupted because of the volume decrease (Balny & Masson, 1993). During pressurization, disulfide bonds are formed via decreasing the distances between sulfhydryl groups (Cheftel & Culioli, 1997). When the pressure is released, proteins unfold and hydrogen bonds and hydrophobic interactions are subsequently formed (Grigera & McCarthy, 2010). Therefore, pressure-induced fish protein gelation is mainly constructed by disulfide bonds, hydrogen bonds and hydrophobic interactions (Sun & Holley, 2011). Formation of hydrophobic interactions induced by high pressure treatment plays an important role in surimi gel with reduced sodium chloride (Cando, Herranz, Borderías, & Moreno, 2015). Blue whiting surimi gel had higher breaking force when its paste was subjected to pressurization at 375 MPa for 20 min (Pérez-Mateos, Lourenço, Montero, & Borderias, 1997). Recently, Liang, Guo, Zhou, Xiao, and Liu (2016) reported that

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bighead carp gels treated at pressures above 300 MPa for 30 min exhibited higher gel strength, compared to traditional two-step heated gels. High pressurization was able to unfold the muscle proteins in surimi paste. The exposed reactive groups on domains of proteins could undergo cross-linking by phenolics incorporated. As a consequence, the gel strength of surimi could be enhanced. However, no information regarding the use of phenolic extract in conjunction with pressurization for preparation of surimi gel exists. Therefore, this study aimed to investigate the effect of ECHE at different levels on the properties of surimi gel from sardine induced by pressurization without and with subsequent heating in comparison with conventional (two-step) heating.

2. Materials and methods

2.1. Chemicals

All chemicals were of analytical grade. Sodium dodecyl sulfate (SDS) and β-mercaptoethanol (β-ME) were obtained from Sigma Aldrich, Inc (St. Louis, MO, USA). *N,N,N′,N′*-tetramethyl ethylene diamine (TEMED), acrylamide and bisacrylamide were purchased from Fluka (Buchs, Switzerland). Ethanol, trichloroacetic acid and acetic acid were procured from Merck (Darmstadt, Germany). Sodium chloride and urea were obtained from RCI Labscan (Bangkok, Thailand).

2.2. Preparation of coconut husk

Husk of coconut (*Cocos nucifera* Linn.) was collected from a local market in Hat Yai, Songkhla Province, Thailand and transported to the Department of Food Technology, Prince of Songkla University, Hat Yai, Thailand. Husk sample was prepared as per the method of Buamard and Benjakul (2015). Husk was manually defibered and ground using a mill (IKA Labortechnik colloid mill, Selangor, Malaysia). The prepared sample was sieved using a stainless-steel screen tray with a sieve size of 0.18 mm. The obtained powder was placed in a polyethylene bag, sealed and kept at room temperature until use.

2.3. Preparation of ethanolic coconut husk extract

Coconut husk powder (10 g) was subjected to extraction using 350 mL of ethanol (60 mL ethanol/100 mL) according to the method of Buamard and Benjakul (2015). The extraction was performed at room temperature (28–30 °C) for 3 h by continuous stirring, followed by filtration through a Whatman filter paper No.1 (Whatman International Ltd., Maidstone, UK). The filtrate was evaporated at 40 °C using an Eyela rotary evaporator (Tokyo Rikakikai, Co. Ltd., Tokyo, Japan) and purged with nitrogen gas to remove the residual ethanol. The extract was then dried using a Scanvac Model Coolsafe 55 freeze dryer (Coolsafe, Lynge, Denmark) to obtain the dry extract. Dried extract was powdered using a mortar and pestle. The powder named 'ECHE' was transferred into an amber bottle and stored in a desiccator until use.

2.4. Preparation of surimi gel added with ECHE using different gelation processes

Frozen surimi, AA grade, from sardine (*S. albella*) was purchased from Man A Frozen Food Co., Ltd. (Songkhla, Thailand) and kept at −20 °C until use, but not longer than one month. Surimi was tempered in running water (25–28 °C) until the core temperature reached 0–2 °C. The surimi was chopped into small pieces. Subsequently, salt (2.5 g/100 g surimi) was added into the prepared surimi. The mixture was blended using a mixer (National Model MK-5080M, Selangor, Malaysia) at a speed of 2200 rpm for 1 min. During the blending, the temperature was maintained below 10 °C.

ECHE was firstly dissolved in cold distilled water and pHs of solution was adjusted to 7. ECHE solution was added into surimi paste to obtain different levels (0.025, 0.05, 0.075 and 0.10 g extract/100 g protein). The moisture content of surimi paste was adjusted to 80 g/100 g with cold distilled water. Subsequently, the mixture was chopped for 30 s, followed by 10 s of a rest interval for a total time of 3 min to avoid heat generated. The paste was stuffed into a polyvinylidene chloride casing with a diameter of 2.5 cm. Both ends were sealed tightly and subjected to different gelation processes.

To prepare high pressure treated gel, casings containing surimi paste were firstly heat sealed in a high-pressured polyethylene bag. The packed samples were transferred into the working chamber of a high-pressure rig (S-FL-850-9-W model, Stansted Fluid Power Ltd, Essex, UK) containing low-compressibility fluid (castor oil/ethanol: 1:4, v/v). The surimi pastes containing ECHE at various levels were pressurized at 300 MPa for 30 min. From the preliminary study, pressurization at 300 MPa for 30 min yielded sardine surimi gel with the highest breaking force (data not shown). The temperature in the pressurization chamber was below 30 °C. The core temperature of surimi gels was approximately 20 °C at the end of pressurization. The resulting gels were termed 'HP'. After being pressurized, another portion of resulting gels was subsequently heated at 90 °C for 20 min in a temperature-controlled water bath (Memmert, D-91126, Schwabach, Germany). Gels were then cooled in iced water for 30 min. The gels obtained were referred to as 'HP/H'.

For gel prepared by conventional method, paste stuffed in casing was set at 40 °C for 30 min, followed by heating at 90 °C for 20 min. Gels were cooled in iced water for 30 min. Gel was termed 'S/H'. S/H gel added with ECHE at a level of 0.075 g/100 g protein was also prepared. This level of ECHE yielded S/H gel with the highest breaking force (Buamard & Benjakul, 2015).

All gels including HP, HP/H and S/H gels were stored at 4 °C for 24 h prior to analyses.

2.5. Analyses

2.5.1. Breaking force and deformation

Breaking force and deformation of surimi gels were determined using a texture analyzer (Model TA-XT2, Stable MicroSystems, Godalming, Surrey, UK) equipped with a spherical plunger (diameter 5 mm) as described by Benjakul, Visessanguan, and Srivilai (2007). The force to puncture into the gel (breaking force) and the distance, at which the plunger punctured into the gel (deformation), were both recorded.

2.5.2. Texture profile analysis

Gel samples were subjected to texture profile analysis (TPA) following the method of Kaewudom, Benjakul, and Kijroongrojana (2013) using a texture analyzer (Model TA-XT2, Stable MicroSystems, Godalming, Surrey, UK) with a slight modification. A cylinder probe (diameter 35 mm) was used for determination of hardness, springiness, cohesiveness, gumminess and chewiness.

2.5.3. Expressible moisture contents

Expressible moisture content of surimi gel was measured according to the method of Benjakul et al. (2007). Cylindrical gel samples (a thickness of 5 mm and weight of X g) were placed between three pieces of Whatman filter paper No.1 at the bottom and two pieces on the top. After the standard weight (5 kg) was placed on the top of the sample for 2 min, the weight of sample (Y) was measured. Expressible moisture content was calculated as follows:

$$\text{Expressible moisture (\%)} = [(X–Y)/X] \times 100$$

2.5.4. Whiteness

Whiteness of gel samples was determined using a colorimeter (HunterLab, Colorflex, Hunter Associates Laboratory, Reston, VA, USA).