INTERNATIONAL JOURNAL OF REFRIGERATION 67 (2016) 345–354

Available online at www.sciencedirect.com

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journal homepage: www.elsevier.com/locate/ijrefrig

Effect of phosphate and bicarbonate replacers on quality changes of raw and cooked Pacific white shrimp as influenced by the repeated freeze–thawing

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ARTICLE INFO

Article history:
Received 30 October 2015
Received in revised form 8 January 2016
Accepted 12 January 2016
Available online 21 January 2016

Keywords:
Shrimp
Phosphate
Monosodium glutamate
Quality
Freeze–thaw

ABSTRACT

The effect of different soaking solutions and varying numbers of freeze–thaw cycles on the quality of raw and cooked Pacific white shrimp was investigated. The soaking solutions included 1) 0.75% NaOH, pH 11.5 (alkaline soaking solution; ASS), 2) ASS with 3% monosodium glutamate (pH 11.5) (ASS + 3% MSG) and 3) 2.5% NaCl containing mixed phosphates (M-P). Higher protein solubility was observed in raw shrimp treated with ASS + 3% MSG, compared with other treatments ($P < 0.05$), regardless of the number of freeze–thaw cycles. Raw shrimp treated with ASS + 3% MSG or M-P showed the lowest drip loss after 5 freeze–thaw cycles. No α-glucosidase (AG) or β-N-acetyl-glucosaminidase (NAG) activities were found in the raw shrimp treated with ASS + 3% MSG and M-P at all freeze–thaw cycles tested. As more freeze–thaw cycles were applied, the a*-value (redness) of raw shrimp increased ($P < 0.05$), while the a* value of cooked shrimp treated with ASS containing 3% MSG decreased ($P < 0.05$). The shear force of both raw and cooked shrimp with all treatments increased when freeze–thaw cycles increase up to 3 cycles ($P < 0.05$); however, it drastically decreased after 5 freeze–thaw cycles ($P < 0.05$). Therefore, treatment of shrimp with 0.75% NaOH containing 2.5% NaCl and 3% monosodium glutamate (pH 11.5) could retard the deteriorative change induced by freeze–thawing process.

Effet des substituts de phosphate et de bicarbonate sur les changements de qualité des crevettes blanches crues et cuites du Pacifique résultant de phases de congélation-décongélation répétées

Mots clés : Crevette ; Phosphate ; Glutamate de sodium ; Qualité ; Congélation-décongélation

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http://dx.doi.org/10.1016/j.ijrefrig.2016.01.010
0140-7007/

Nomenclature

AG	α-glucosidase
ASS	alkaline soaking solution
°C	degree Celsius
KCl	potassium chloride
M-P	mixed phosphates
MSG	monosodium glutamate
NaCl	sodium chloride
NAG	β-N-acetyl-glucosaminidase
NaOH	sodium hydroxide
SD	standard deviation
xg	times gravity

1. Introduction

Quality of fish and shellfish is of paramount concern for processors and consumers. To increase the shelf-life and reduce the rate of biochemical and microbial degradation, different preservative methods, mainly based on low temperatures, particularly freezing, have been used for distribution and storage of products (Gallart-Jornet et al., 2007). It has been known that the extended frozen storage is associated with quality changes, mainly attributed to protein denaturation and lipid oxidation (Kittiphattanabawon et al., 2012). Additionally, thawing is necessary for frozen food before any additional subsequent food processing or cooking (Xia et al., 2012). Repeated freeze–thawing is a common practice in retail shop or restaurant (Boonsumrej et al., 2007). However, quality deterioration takes place during freezing and thawing process, especially texture, flavor and color due to osmotic removal of water, mechanical damage, as well as cross-linking and aggregation of myofibrillar protein (Benjakul et al., 2003). Especially for fresh water prawn, the freeze–thaw process is found to be detrimental to overall physicochemical and textural quality and affects its thermal properties. Rattanasatheirn (2008) demonstrated that freezing and thawing disrupt muscle cells and cause the release of some enzyme such as α-glucosidase (AG) and β-N-acetyl-glucosaminidase (NAG). Freeze–thawing induced shrimp protein denaturation, tissue disruption and damage to muscle fibers (Sriket et al., 2007). Furthermore, increasing freeze–thaw cycles of shrimp increased the thiobarbituric acid reactive substances and cutting force, but decreased salt-soluble protein. The spacing between the muscle fibers increased and the muscle fibers were disrupted as the number of freeze–thaw cycles increased (Boonsumrej et al., 2007). From our previous study, shrimp treated with 0.75% NaOH containing 2.5% NaCl in the presence of 3% MSG (pH 11.5) provided the highest cooking yield and overall likeness score (unpublished data). Nevertheless, no information regarding the quality changes of those shrimp in both raw and cooked forms as affected by freeze–thawing process has been reported. Therefore, the objective of this work was to investigate the quality changes of shrimp with different treatments after being subjected to multiple freeze–thawing.

2. Materials and methods

2.1. Preparation of shrimp with different treatments

2.1.1. Collection and preparation of shrimp

Pacific white shrimp (*Litopenaeus vannamei*) (55–60 shrimp/kg) were purchased from a local market in Hat Yai, Songkhla province, Thailand. Shrimp with storage time less than 6 h after capture were stored in the insulated box containing ice using a shrimp/ice ratio of 1:2 (w/w). The samples were transported to the Department of Food Technology, Prince of Songkla University within 2 h. Upon arrival, shrimp were cleaned using tap water. Shrimp were peeled and deveined manually. Prepared shrimp were placed in polyethylene bag and stored in ice until used.

2.1.2. Treatments of shrimp

Shrimp (peeled and deveined) were mixed with different alkaline soaking solutions including 1) 0.75% NaOH containing 2.5% NaCl (pH 11.5) (ASS), 2) ASS containing 3% MSG (pH 11.5) (ASS + 3% MSG) and 3) 2.5% NaCl containing 3% mixed phosphates (sodium tripolyphosphate + tetrasodium pyrophosphate; 1:2, w/w) (M-P). The mixtures were stirred gently for 30 min at 4 °C and allowed to stand at 4 °C for 30 min. After treatment, the shrimp were placed on the plastic screen for 5 min (4 °C) to drain off solution. Sample without soaking was used as the control.

After treatments, those shrimp were divided to two portions. The first portion was used as raw shrimp. Another portion was cooked by steaming until the core temperature of the second segment of shrimp reached 85 °C. The samples were cooled rapidly in iced water for 1 min and then the prepared samples were drained on a screen for 5 min at 4 °C.

2.2. Quality changes of raw and cooked shrimp subjected to various freeze–thaw cycles

Raw and cooked shrimp without and with different treatments were packed in the polyethylene bag and frozen at –18 °C, using an air blast freezer for 24 h. The samples were then stored at –18 °C for 24 h. Thereafter, the frozen samples were thawed using running water (25–26 °C). The thawed samples were frozen as previously described, followed by thawing. The freeze–thaw cycles were 0, 1, 3 and 5 cycles (Srinivasan et al., 1997b). Both raw and cooked shrimp were ground until the uniformity was obtained and used for all analyses, except for color and shear force, in which the whole shrimp were used. Raw prepared samples were analyzed as follows:

2.2.1. Determination of protein solubility

Solubility was determined according to the method of Rattanasatheirn (2008). One gram of sample was mixed with 20 mL of 0.6 M KCl. The mixture was homogenized for 1 min at a speed of 12,000 rpm using an IKA homogenizer (Salangor, Malaysia). The homogenate was stirred at 4 °C for 4 h, followed by centrifugation at 8500 × *g* for 30 min at 4 °C. To 10 mL of supernatant, cold 50% (w/v) trichloroacetic acid was added to obtain the final concentration of 10%. The precipitate was washed with 10% trichloroacetic acid and solubilized in 0.5 M