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Effects of the anti-microbial peptide pardaxin plus sodium erythorbate dissolved in different gels on the quality of Pacific white shrimp under refrigerated storage

Wei-Hsuan Hsu [a], Ying-Jang Lai [b, **], She-Ching Wu [c, *]

[a] Biochemical Process Technology Department, Center of Excellence for Drug Development, Biomedical Technology and Device Research Laboratories, Industrial Technology Research Institute, Hsinchu, Taiwan, ROC
[b] Department of Food Science, National Quemoy University, Quemoy, Taiwan, ROC
[c] Department of Food Science, National Chiayi University, Chiayi, Taiwan, ROC

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ABSTRACT

Pardaxin (33 amino acids; GFFALIPKIISSPLFKTLLSAVGSALSSSGGQE) is an antimicrobial peptide originally isolated from marine fish species (*Pardachirus marmoratus*). Pardaxin is a safe and natural peptide used as an anti-microbial agent. This study aimed to investigate (1) the optimal pardaxin concentration alone or in combination with various gums for coating on shrimp to maintain quality during storage at 4 °C, and (2) the potentials of pardaxin and sodium erythorbate (SE) to suppress bacteria growth and effect antioxidation, respectively. We found that 1% xanthan gum and 0.5% xanthan gum + 0.5% guar gum (mixed-XG) coating on shrimp yielded a film that countered oxidation and weight loss and maintained shrimp quality (including texture profile, sensory quality, and melanosis suppression) through inhibition of peroxide value and total volatile basic nitrogen. Subsequently, pardaxin alone or in combination with SE was added into mixed-XG for evaluating shrimp quality during storage at 4 °C. The results indicated that mixed-XG with 0.5% SE and 0.25% pardaxin could significantly suppress bacteria growth and potentially effect antioxidation. Overall, these findings indicate that storing fresh shrimp in specific conditions (mixed XG + 0.5% SE + 0.25% pardaxin) might serve as an effective post-harvest treatment for preserving the freshness of shrimp and prolonging shelf life.

1. Introduction

Pacific white shrimp (*Litopenaeus vannamei*) is an economically important species. However, this high-value crustacean is very perishable owing to the biochemical, microbiological, or physical changes that occur during post-mortem storage, which results in limited shelf life of the product (Asik & Candogan, 2014). Traditional methods for shrimp preservation such as cold storage, freezing, and chilling cannot effectively suppress spoilage (Arancibia, Lopez-Caballero, Gomez-Guill_en, & Montero, 2015). For example, frozen storage is an important preservation method used in the shrimp processing industry. However, despite microbial spoilage being effectively terminated, quality deterioration, e.g., texture, flavor, and color, still occurs during frozen storage (Sriket, Benjakul, Visessanguan, & Kijroongrojana, 2007). Furthermore, whereas frozen storage can effectively retard physicochemical changes of shrimp, black spot formation (melanosis) might occur after thawing (Diaz-Tenorio, Garcia-Carreno, & Pacheco-Aguilar, 2007). As a consequence, freezing drastically reduces the product market value, leading to considerable financial loss (Kim, Marshall, & Wei, 2000).

Synthetic preservatives such as antioxidants, chelating agents, and antimicrobial compounds may be applied to improve the shelf life of foods. Recently, there has been increasing interest in developing materials with film-forming capacity that exhibit antimicrobial properties, which help improve food safety and shelf life (Dutta, Tripathi, Mehrotra, & Dutta, 2009; Nirmal & Benjakul, 2010). Edible coatings can improve the quality of food products by retarding lipid oxidation, preventing the loss of protein

* Corresponding author. Department of Food Science, College of Life Science, National Chiayi University, Taiwan, ROC.
** Corresponding author. Department of Food Science, National Quemoy University, Quemoy, 89250, Taiwan, ROC.
E-mail addresses: d91641006@gmail.com (Y.-J. Lai), scwu@mail.ncyu.edu.tw (S.-C. Wu).

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functionality thus reducing flavor, discoloration, and moisture loss (Arancibia et al., 2015).

Antimicrobial peptides (AMPs) belong to a large family of peptide molecules that typically contain <100 amino acids. Pardaxins is identified as pore-forming membrane lytic peptides and which has been endowed with various concentration-dependent biological functions (Shai, 1994). Subsequently, their antibacterial activities against both Gram-negative and Gram-positive organisms were discovered (Saberwal & Nagaraj, 1993). Notably, the antibacterial activities of pardaxins were found to be comparable or even higher than many other host defense AMPs such as magainin, cecropins, and dermaseptins (Sitaram & Nagaraj, 1999). On the other hand, the inhibitory effect of AMPs against bacteria for preserving the quality of white shrimp storage is never evaluated in past years.

Xanthan gum, a water soluble pentasaccharide produced from the fermentation of carbon sources by the plant-pathogenic bacterium *Xanthomonas campestris*, consists of D-glucosyl, D-mannosyl, and D-glucuronyl acid residues (Datta, Mody, Gopalsamy, & Jha, 2011). It also serves as a stabilizer for a wide variety of suspensions, emulsions, and foams (Becker, Katzen, Pühler, & Ielpi, 1998). Xanthan gum is the most versatile elastic thickener and easy-to-use hydrocolloid. It can be used in hot or cold applications, is extremely powerful in small quantities, provides a rich creamy mouth feel, and works synergistically with many other ingredients. Xanthan gum is very stable toward temperature variations and it is effective in alkaline, acid, and even salty solutions. Xanthan gum can also withstand freeze/thaw cycles and functions as an excellent gluten replacement providing sponginess and firmnesss (Datta et al., 2011). Amounts of 0.05–0.15% can be used to slightly thicken smoothies, 0.25%–0.5% for thin sauces, and up to 0.8% will create a syrupy texture. Higher concentrations may be used in baked goods and for other special applications (Prado, Kim, Qzen, & Mauer, 2005).

In addition, guar gum, a nonionic galactomannan, is used as an economical thickener and stabilizer in the food industry and is often combined with xanthan gum to yield high viscosity (Prado et al., 2005). Arabic gum consists of six carbohydrate moieties and a small proportion of protein (polypeptide chain). It possesses high water solubility, low solution viscosity, and low interfacial activity (Islam, Phillips, Sljivo, Snowden, & Williams, 1997). Guar and Arabic gums are also used in frozen food to maintain quality (Rezaei, Khomeiri, Kashaninejad, & Aalami, 2011). Considering these benefits, in the current study we investigate the ability of different gums plus pardaxin and sodium erythorbate to impact the quality of white shrimp during frozen storage. The aim of this study is to investigate the application of pardaxin corporate with different gums for maintain of shrimp quality.

2. Materials and methods

2.1. Chemicals

L-beta-(3,4 dihydroxylphenyl) alanine (L-DOPA), xanthan gum, Arabic gum, guar gum, sodium erythorbate, malonaldehyde bis (dimethyl acetal), boric acid, methyl red, and thiobarbituric acid (TBA) were purchased from Sigma-Aldrich (St. Louis, MO, USA). Trichloroacetic acid (TCA), ammonium sulfate, potassium carbonate and standard plate count agar (PCA) were obtained from Merck (Darmstadt, Germany). Live fresh Pacific white shrimps (*L. vannamei*) with the size of 80–85 shrimps/kg were purchased from the local market (Chiayi, Taiwan).

2.2. Coating solution preparation, coating, and storage

In experimental group-I, the coating solutions were divided into (1) water, (2) 1% xanthan gum, (3) 1% Arabic gum, (4) guar gum, (5) 0.5% xanthan gum + 0.5% guar gum (mixed XG), (6) 0.5% xanthan gum + 0.5% Arabic gum (mixed XA), and (7) 0.5% guar gum + 0.5% Arabic gum (mixed GA). In experimental group-II, the coating solutions were divided into (1) water, (2) mixed XG solution, (3) 0.5% sodium erythorbate (SE), (4) 0.5% SE dissolved in mixed XG solution, (5) 0.25% pardaxin, (6) 0.25% pardaxin dissolved in mixed XG solution, and (7) 0.5% SE + 0.25% pardaxin dissolved in mixed XG solution. These coating solutions were freshly prepared for each experiment. During coating, the shrimp were respectively immersed into different coating solutions at 4 °C for 30 min according to Yuan, Lv, Tang, Zhang, and Sun (2016) and the shrimp/solution ratio was 1:2 (w/v). After dipping, the shrimp were drained at ambient temperature for 3 min and then coated twice by different coating solutions. The shrimp samples from each treatment were covered in plastic bags maintained at 4 °C. The TPA of raw shrimp was investigated to confirm the quality variation of between before and after storage. For TPA evaluation of shrimps ($n = 20$) were carried out by 10 shrimps at day 0 ($n = 10$) and by another 10 shrimps at day 15 ($n = 10$). At day 0, the 10 coated-shrimps were washed and then investigated the TPA values. At day 15, the TPA of another 10 shrimps was measured. This is the first separate replication. Subsequently, experiments of weight loss, color variation, melanosis scores, total bacteria counts, TVBN, peroxide value, and thiobarbituric acid (TBA) were used the same shrimps ($n = 10$/group). Briefly, coated-shrimps were measured weight and then were storage at day 0. And weight and color variation were assayed after coated-shrimp at 3, 6, 9, 12, and 15 days of storage period. After 15 days, melanosis scores and total bacteria counts of shrimps were measured. Subsequently, the whole shrimps (from head to tail) were cut in half. One half-shrimps was used to evaluate melanosis and total bacteria counts, and another one was storage at −80 °C until to further determine TVBN, peroxide value (PV), and thiobarbituric acid (TBA) index. Above experiments are the secondary separate replication ($n = 10$). For evaluation of sensory attributes. The flavor was carried out by another coated-shrimps after 15 days storage (shrimps $n = 20$ in each group).

2.3. Melanosis assessment

Melanosis assessment of Pacific white shrimp was conducted through visual inspection by six panelists using ten-point scoring according to the method of Montero, Avalos, and Perez-Mateos (2001). Panelists were asked to assign a melanosis score (0–10) for the shrimp, where = absent; 2 = slight (up to 20% of shrimp surface affected); 4 = moderate (20%–40% affected); 6 = notable (40%–60% affected); 8 = severe (60%–80% affected); and 10 = extremely heavy (80%–100% affected).

2.4. Color analysis

Instrumental color analysis of the shrimp was performed using a Hunter Lab colorimeter (Hunter Associates Laboratory, Inc., Reston, VA, USA), calibrated with a white tile having standard values of $X = 81.0$, $Y = 85.8$ and $Z = 91.2$ with corresponding L^*, a^* and b^* values of 67.81, 19.56 and 58.16, respectively as provided by the manufacturer. Color was determined in three zones (head, body and tail) on the shrimp shell. For each sample, triplicate measurements were taken at each shell zone and the average values of six samples were recorded. Lightness component is L^* (ranges from 0 to 100), and chromatic components are a^* (redness/greenness (±)) and b^* (yellowness/blueness (±)) (Papadakis, Abdul-Malek, Kamdem, & Jam, 2000) that were determined. The total color differences (ΔE values), which indicate the magnitude of color difference between shrimps at the beginning of storage and after the