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Quality of Frozen Black Tiger Shrimp (*Penaeus monodon*) under a Low-Density Polyethylene Bag Coextruded with Butylated Hydroxyanisole

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Abstract.

Black tiger shrimp (*Penaeus monodon*) were considering important in export. It is an excellent source of dietary protein. Lipid oxidation development during frozen storage (–18 °C) of black tiger shrimp (*Penaeus monodon*) was studied. Frozen shrimps were packed in low-density polyethylene bags with and without butylated hydroxyanisole added (BHA-LDPE and LDPE respectively). Frozen shrimps stored with no package were used as control. Periodically sampling was taken during storage (0, 3, 6, 9 and 12 months) to observe the quality of the frozen shrimp. Physical (pH and texture) and chemical (peroxide value and thiobarbituric acid) analyses were performed. By this approach, the plastic bag with butylated hydroxyanisole effectively limited the lipid oxidation of shrimp during frozen storage.

Keywords: *Black tiger shrimp, low-density polyethylene, butylated hydroxyanisole, lipid oxidation, peroxide value, thiobarbituric acid*

I. INTRODUCTION

The black tiger shrimp (*Penaeus monodon*) has high economic value, and is one of the important cultured species in the Mekong delta, Vietnam (Nguyen Thi Ngoc Anh et al., 2018). Shrimp is one of the most delicious seafoods and is part of almost every nation's traditional meal. With its relatively lower lipid content (~ 1%), the DV (%) of 100 g shrimp for an adult human is 75%, 70% and 35% for eicosapentanoic acid + docosahexanoic acid, essential amino acids (methionine, tryptophan and lysine) and protein respectively. The lower atherogenic (0.36) and thrombogenic (0.29) indices of shrimp show its cardio-protective nature. Shrimps have low fat, less cholesterol and high PUFA content (J. Syama Dayal et al., 2013).

Fatty acids present in this species are highly susceptible to oxidation, this ofen determines the type of handling, storage, distribution and shelf life of the product (Leland, 1997; Losada et al, 2004; Aubourg et al., 2005; Rodríguez et al., 2007; Chaouqy et al., 2008). Antioxidants, which prevent the formation of free radicals (hydroperoxides), can be used to delay the deterioration due to lipid oxidation effect (Kim et al., 2006; Sarkardei & Howell et al., 2008; Rostamzad et al., 2010). Another alternative is the use of low temperatures, and the use of oxygen impermeable containers (Rodríguez et al., 2007). Films with added antioxidants have been used in order to prevent the sierra's muscle oxidation during freezing. Torres-Arreola et al. (2007) studied the effect on lipid oxidation of sierra fillets packaging with a film of low density polyethylene containing butylhydroxytoluene, finding a positive effect of the antioxidant material on the quality of the fillets assessed during frozen storage (4 months). Rancidity development during frozen storage (–20 °C) of sierra fish (*Scomberomorus sierra*) was studied. Fillets were packed in low-density polyethylene films with and without butylated hydroxytoluene added. Lipid oxidation increased with ice storage time in fish muscle without film packing, being greater than the film packed muscle (with and without antioxidant). An effect of previous ice storage time was observed on the frozen product (in all treatments). However, fish muscle with film packing containing antioxidant showed less lipid deterioration (Herlinda Sdtd-Valdez et al., 2015).

There were several researches mentioned to the effectiveness of packaging to shelf life of frozen shrimp. The BHT-incorporated PE film was able to inhibit lipid oxidation in both fish muscle and oil (Chen-Huei Huang, Yih-Ming Weng, 2007). A study was undertaken to find the effect of packaging on the shelf life of frozen condition. Fresh shrimp were packed in CAP (Control atmospheric pack), TAP (Treated atmospheric pack), CVP (Control vacuum pack) and TVP (Treated vacuum pack) samples and record the shelf life (Sawant S S et al., 2012). A study were to determine the effects of combined antioxidants (Propyl gallate (PG) and sodium ascorbate) and packing on lipid oxidation in salted dried snakehead fish during storage at refrigerated temperature (4°C) (Nitipong, J. et al., 2014). Nano-TiO2-modified low-density polyethylene (NTLDPE) packaging was prepared by blending LDPE with nano-TiO2. The effects of NTLDPE packaging on quality of Pacific white shrimp during storage at 4 °C were investigated (Zisheng Luo et al., 2015).

Ojective of the present study focused on the effectiveness of low-density polyethylene bag with and without butylated hydroxylanisole on some physicochemical characteristics of frozen black tiger shrimp during storage.

II. MATERIALS AND METHOD

2.1 Sample preparation

Black tiger shrimps (*Penaeus monodon*) were collected from Soc Trang province, Vietnam. They were raised following Global GAP standard without using antibiotic to ensure food safety. After collecting, they must be kept in ice chest below 8^{o}C and quickly transferred to laboratory for experiments. Head on shell on black tiger shrimps were frozen to -18^{o}C ready for investigation. Low density polyethylene added with 30 mg/g of BHA (BHA-LDPE) manufactured by an extrusion process were used. Moreover, an LDPE bag without BHT was used. Frozen shrimps stored with no package were used as control. Periodically sampling was conducted during storage (0, 3, 6, 9 and 12 months) on the quality of the frozen shrimp.

Figure 1. Frozen Black tiger shrimp (*Penaeus monodon*)

2.2 Physico-chemical evaluation

pH was monitored using a digital pH-meter. Texture (shear force, lb/in^2) was measured by penetrometer. Peroxide value (mEqO2/ kg) was determined using the CDR FoodLab® instrument. Thiobarbituric acid (mg maloaldehyde/ kg shrimp) was measured by 1,1,3,3-tetraethoxypropane (Torres-Arreola et al., 2007).

2.3 Statistical analysis

The experiments were run in triplicate with three different lots of samples. Data were subjected to analysis of variance (ANOVA) and mean comparison was carried out using Duncan's multiple range test (DMRT). Statistical analysis was performed by the Statgraphics Centurion XVI.

III. RESULT & DISCUSSION

3.1 Physical changes of frozen black tiger shrimp during storage by different packagings

pH changes of frozen black tiger shrimps during storage are shown in table 1. The control has a signifcant increase ($p<0.05$) during preservation. Meanwhile, frozen shrimps stored in LDPE and BHA-LDPE showed no increase throughout the ice storage process ($p\geq0.05$), indicating that the use of packaging delayed changes in shrimp pH during ice storage.

Texture is an important quality factor in seafood which depends on species, age, size, fat, protein content, handling and storage conditions (Kagawa et al., 2002). Table 2 shows changes in texture of frozen shrimp during preservation. The control showed the highest loss of firmness, while frozen shrimp stored in packaging having BHA had more firmness probably due to the effect of BHA on lipids present in the muscle, thus delaying possible protein-lipid interactions, as has been documented by Torres-Arreola et al. (2007) that lipid oxidation in fish muscle can cause changes in texture due to the effect of protein-lipid interactions during frozen storage. This protein-lipid interaction effect, together with a modification in the protein-water interactions and endogenous proteolytic activity of the muscle are the main factors that affect the integrity of the muscle fibers

Table 1. pH changes of frozen black tiger shrimps during storage by different packagings

Storage (months)	*Control*	*LDPE*	*BHA-LDPE*
0	6.32±0.01^{a}	6.32±0.01^{a}	6.32±0.01^{a}
3	6.63±0.02^{a}	6.35±0.03^{ab}	6.33±0.02^{b}
6	6.89±0.03^{a}	6.41±0.02^{ab}	6.37±0.01^{b}
9	6.95±0.00^{a}	6.47±0.00^{ab}	6.39±0.03^{b}
12	7.27±0.01^{a}	6.50±0.02^{ab}	6.40±0.01^{b}

Note: the values were expressed as the mean of three repetitions; the same characters (denoted above), the difference between them was not significant (α = 5%).

Table 2. Texture (lb/in^2) changes of frozen black tiger shrimps during storage by different packagings

Storage (months)	*Control*	*LDPE*	*BHA-LDPE*
0	14.25±0.02^{a}	14.25±0.02^{a}	14.25±0.02^{a}
3	14.01±0.01^{a}	14.22±0.03^{a}	14.24±0.01^{a}
6	13.93±0.03^{a}	14.21±0.00^{a}	14.24±0.00^{a}
9	13.88±0.00^{a}	14.18±0.01^{a}	14.22±0.00^{a}
12	13.84±0.02^{a}	14.15±0.03^{a}	14.21±0.01^{a}

Note: the values were expressed as the mean of three repetitions; the same characters (denoted above), the difference between them was not significant (α = 5%).

Table 3. Peroxide value (mEqO2/ kg) changes of frozen black tiger shrimps during storage by different packagings

Storage (months)	*Control*	*LDPE*	*BHA-LDPE*
0	0	0	0
3	0.25±0.03^{a}	0.17±0.02^{b}	0.11±0.01^{c}
6	0.36±0.01^{a}	0.22±0.00^{b}	0.13±0.02^{c}
9	0.42±0.00^{a}	0.25±0.01^{b}	0.14±0.00^{c}
12	0.53±0.01^{a}	0.29±0.00^{b}	0.16±0.03^{c}

Note: the values were expressed as the mean of three repetitions; the same characters (denoted above), the difference between them was not significant (α = 5%).

Table 4. Thiobarbituric acid (mg maloaldehyde/ kg) changes of frozen black tiger shrimps during storage by different packagings

Storage (months)	*Control*	*LDPE*	*BHA-LDPE*
0	0	0	0
3	3.27±0.01[a]	1.03±0.02[b]	0.45±0.00[c]
6	4.69±0.02[a]	1.29±0.03[b]	0.51±0.01[c]
9	6.19±0.00[a]	1.38±0.01[b]	0.53±0.02[c]
12	7.35±0.02[a]	1.55±0.02[b]	0.55±0.01[c]

Note: the values were expressed as the mean of three repetitions; the same characters (denoted above), the difference between them was not significant (α = 5%).

Release of butylated hydroxytoluene from an active film packaging to asadero cheese and its effect on oxidation and odor stability was observed. The film added with 8 mg/g of BHT maintained the same levels of oxidized odor from 20 to 100 d of storage (C. D. Soto-Cantu et al., 2007).
Nano-TiO2-modified low-density polyethylene (NTLDPE) packaging was prepared by blending LDPE with nano-TiO2. The effects of NTLDPE packaging on quality of Pacific white shrimp during storage at 4 °C were investigated. Results showed that NTLDPE lowered the K value by 28.50%, while increased sensory score by 30.77% in comparison with the control. NTLDPE packaging retarded the decrease of whiteness and water holding capacity and the increase of melanosis score based on the signs of freshness and deterioration of shrimp. Furthermore, NTLDPE packaging reduced total viable counts (TVC) by 6.42% and total volatile basic nitrogen (TVB-N) contents were 14.82% lower than that of control. TVB-N content and TBARS value, as well as polyphenol oxidase activity and TVC, were maintained and shrimp remained a commercial acceptability for 8 days. The overall results indicated that NTLDPE packaging could preserve the quality and extend the shelf-life of Pacific white shrimp (Zisheng Luo et al., 2015).

3.2 Chemical changes of frozen black tiger shrimp during storage by different packagings

Shrimp lipids are characterized by a high degree of unsaturation in the form of multiple double bonds in the fatty acids and are generally susceptible to molecular oxygen. Production of off-flavor compounds constitutes the primary quality deterioration observed during lipid oxidation, although the process of lipid oxidation can also lower nutritional quality and modify texture and color. From table 3, signifcant differences in peroxide value (mEqO2/ kg) of the three treatments applied during all stages of sampling were found ($p<0.05$), where the control showed the highest values compared to the frozen shrimp packaged with and without antioxidants (BHA-LDPE and LDPE). BHA incorporated to a LDPE packaging could delay the formation of peroxides. Peroxides are intermediate metabolites during lipid oxidation in foods, so their formation increases up to a maximum value to later start decreasing encouraging the production of aldehydes and ketones as final oxidation products. Therefore the use of packaging with BHA significantly delayed the formation of peroxides.
Regarding to thiobarbituric acid (mg maloaldehyde/ kg), there was significant differences ($p<0.05$) among the three treatments executed (table 4). It was suggested that a marked lipid oxidation in the muscle occurred due to the high interaction with oxygen.
Fish fillets were wrapped by BHT-incorporated film and stored at different temperatures for various time periods. When the concentration of BHT in the original preparation was 40 mg/g, BHT-incorporated film wrapped fish muscle produced approximately 50% less TBARS than the control group at −20C. Peroxide value of fish oil covered by BHT-incorporated film was 66% less than fish oil covered by PE film when samples were stored at 30C for 24 days. The BHT-incorporated PE film was able to inhibit lipid oxidation in both fish muscle and oil (Chen-Huei Huang, Yih-Ming Weng, 2007). A study were to determine the effects of combined antioxidants (Propyl gallate (PG) and sodium ascorbate) and packing on lipid oxidation in salted dried snakehead fish during storage at refrigerated temperature (4^{o}C). A combination of Propyl gallate and sodium ascorbate were effective in delaying lipid oxidation and showed a greater antioxidant activity in terms of the lower peroxide, thiobarbituric acid values than did not with antioxidants (Nitipong, J. et al., 2014).

IV. Conclusion

Seafood can undergo rapid microbial contamination and growth if subjected to inadequate handling and storage. Microorganisms are the major cause of spoilage in most seafood products contribute to the offensive off-flavors associated with seafood spoilage. In this work, an antioxidant active packaging was developed consisting of a layer made of LDPE to which 30 mg/g of BHA was added and coextruded. A package of low density polyethylene helps keep the muscle more firmly during frozen storage. The addition of butylated hydroxyanisole to the LDPE increases efficiency of muscle texture, delays lipid oxidation during frozen storage.

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