



APPLICATION OF EDIBLE COATING TO PROLONG SHELF LIFE OF DRIED WHITE LEG SHRIMP (*LITOPENAEUS VANNAMEI*)

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Abstract

Shrimp is an important seafood with considerable nutritional and economic value in many countries worldwide. White shrimp (*Litopenaeus Vannamei*) is an excellent source of dietary protein. The principle of drying is to reduce moisture to maximum levels to prevent microorganism growth and also slow down enzymatic or biological reactions that cause food deterioration. Water absorption, microbial cross contamination, lipid oxidation, discoloration are main obstacles in its preservation. Most importantly, rancidity creates bad odor as well as lower product quality and shelf-life. There were some researches using edible coating for frozen white leg shrimp (*Litopenaeus vannamei*). However there was not any research mentioned to the investigation of edible coating to the dried white leg shrimp. Objective of the current research studied the feasibility of edible coating in extending shelf-life of dried shrimp. The dried shrimps were treated by different formulas (N₀: control; N₁: 1.0% whey protein isolate; N₂: 1.0% w/w cacboxymethyl cellulose; N₃: 1.0% w/w corn protein; N₄: 1.0% w/w gelatin) and in different concentration of chitosan (1.0%, 1.5%, 2.0%, 2.5%, 3.0%). The effectiveness of edible coating was based on different values of Water activity (a_w) Elasticity (lb/in²), Astaxanthin (μg/g), Coliform (cfu/g), Peroxide value (mEqO₂/ kg), Thiobarbituric acid (mg malonaldehyde/ kg). All treated samples were analyzed after 12 months of storage at ambient temperature under vaccum packing. Results revealed that the incorporation of 1.0% w/w cacboxymethyl cellulose could inhibit microbial spoilage and lipid oxidation and therefore maintain the sensory score of the dried shrimp for 12 months during storage. The study indicated that the combination treatment with edible coating could be commercially utilized to prolong the shelf-life of the dried shrimp.

Keywords: Dried white leg shrimp, whey protein isolate, cacboxymethyl cellulose, corn protein, gelatin, spoilage, lipid oxidation, sensory

Introduction

Shrimp represents one of the most vital commercial seafood in the world¹. White shrimp (*Litopenaeus vannamei*) was one of the key species in Vietnamese shrimp farming. Vietnam's shrimp exports in 2017 recorded a remarkable growth with a growth of 22.3% compared with 6.7% in 2016. According to the Vietnamese Directorate of Fisheries (D-Fish), the total output of shrimp in the country in 2017 reached 723.8 thousand metric tons (MT). Of that, brackish water shrimp output reached 683.4 thousand MT including 256.4 thousand MT of black tiger shrimp and 427 thousand MT of white shrimp. The area of brackish water shrimp farming was 721.1 thousand ha, of which that for black tiger shrimp was 622.4 thousand ha and that for white shrimp was 98.7 thousand ha. Vietnamese farmers move away from farming black tiger shrimp (*Penaeus monodon*) and change to the white shrimp (*Litopenaeus vannamei*). Farmers in Vietnam, particularly in the Mekong Delta of the country are expanding white shrimp farming area. Exports of white shrimp occupied the largest proportion of 65.6%; those of black tiger shrimp accounted for 23%, the rest was marine shrimp with 11.6%. Regarding to nutritive characteristic of raised white leg shrimp *Litopenaeus vannamei*, it has good source of protein, carbohydrate, lipid, moisture and ash, calcium, sodium, potassium, manganese, copper, chromium (Gunalan *et al.*, 2013). Shrimps have low fat, less cholesterol and high polyunsaturated fatty acid (PUFA) content (Syama Daya *et al.*, 2013).

There were several notable researches mentioned to application of edible coating in white leg shrimp (*Litopenaeus Vannamei*). The effects of 1.0% and 1.5% O-carboxymethyl chitosan (CMC) and 1.0% and 1.5% chitosan (CH) coatings on the quality changes of whiteleg shrimp (*Litopenaeus vannamei*) during refrigerated storage (0 ± 1 °C) of 10 d were investigated. Chitosan and O-carboxymethyl chitosan can be used as promising melanosis

inhibitors as well as antimicrobial agents during refrigerated storage (Jiaying Huang *et al.*, 2012). A study investigated the effects of chitosan coating combined with organic acids on inhibiting *Listeria monocytogenes* in ready-to-eat (RTE) shrimps during storage at 4°C. Chitosan coating combined with acetic acid could be a promising antimicrobial method to prevent the proliferation of *L. monocytogenes* in RTE shrimps with extended shelf life (Min Li *et al.*, 2013). In order to improve the quality of shrimp (*Litopenaeus vannamei*) at refrigerated temperature (4±1°C), the shrimp samples were coated with solutions of chitosan (0, 0.5, 1, 1.5 and 2%), gelatin (0, 2 and 3%) and combination of them in 15 treatment group. Preservative effect of the coatings was evaluated by biochemical analyses, microbiological assays and physical measurements over 8th day of storage time. The findings indicated that 1% chitosan and 3% gelatin based coating was superior to others in preservation spoilage, inhibiting oxidation, improvement physical properties (Farajzadeh *et al.*, 2015). A study evaluated the effect of chitosan coating combined with green tea extract (GTE) on the melanosis formation and quality of Pacific white shrimp (*Litopenaeus vannamei*) during 9 days of storage in ice. Chitosan coating combined with GTE could be used as an effective natural alternative to synthetic antimelanosis agents to inhibit post-mortem melanosis and improve the quality of shrimp during storage in ice (Gaofeng Yuan *et al.*, 2016). A research investigated effect of bioactive coating composed of quince seed mucilage (QSM) incorporating green tea extract (GTE) on oil and water content, lipid oxidation, texture, color and sensory evolution of shrimp after deep-fat frying (Mohammad Noshad *et al.*, 2017). The effect of a layer-by-layer (LbL) electrostatic deposition coating of alginate and chitosan with grapefruit seed extract was investigated on the shelf life of shrimp (*Litopenaeus vannamei*) stored for 15days under refrigeration (4°C). Chitosan and chitosan-alginate treatments could prolong the shelf life of shrimp (Jin-HeeKim *et al.*, 2018). Effect of chitosan-carvacrol

coating on the quality of Pacific white shrimp during iced storage as affected by caprylic acid was examined (Wang, Qianyun *et al.*, 2018). However there was not any research mentioned to the investigation of edible coating to the dried white leg shrimp (*Litopenaeus vannamei*). The aim of this current work was to study the application of edible coating in maintaining product quality of dried shrimp under vacuum packaging at ambient temperature.

Material and Method

Material

White shrimps were collected from Vinh Chau district, Soc Trang province, Vietnam. They must be reared following VietGAP without antibiotic residue to ensure food safety. After collecting, they must be kept in ice chest below 4°C and quickly transferred to laboratory for experiments. They were washed and sanitized under washing tank having 30 ppm chlorine with a support of air bubble blowing to remove foreign matters. Besides white shrimps we also used other material during the research such as chlorine, salt, whey protein isolate, cacboxymethyl cellulose, corn protein, gelatin. Lab utensils and equipments included digital weight balance, Rotronic, stomacher, incubator, colony counter, steaming and dry oven.



(a)



(b)

Fig. 1. : (a) White shrimp (*Litopenaeus vannamei*),
(b) dried shrimp

Researching method

(i) Effect of edible film coating to physicochemical quality, antimicrobial capacity and sensory score of dried shrimp

Raw shrimps were treated with 4.0% salt, 2.0% sorbitol in 20 minutes; boiling in 1.5 minutes. After that they were dried at 55°C to 12% moisture content. After that, the dried shrimps were treated by different formulas (N₀: control; N₁: 1.0% whey protein isolate; N₂: 1.0% w/w cacboxymethyl

cellulose; N₃: 1.0% w/w corn protein; N₄: 1.0% w/w gelatin). The effectiveness of edible coating was based on different values of Water activity (a_w) Elasticity (lb/in²), Astaxanthin (µg/g), *Coliform* (cfu/g), Peroxide value (mEqO₂/ kg), Thiobarbituric acid (mg malonaldehyde/ kg). All treated samples were analyzed after 12 months of storage at ambient temperature.

(ii) Effect of cacboxymethyl cellulose concentration to physicochemical quality, antimicrobial capacity and sensory score of dried shrimp

Raw shrimps were treated with 4.0% salt, 2.0% sorbitol in 20 minutes; boiling in 1.5 minutes. After that they were dried at 55°C to 12% moisture content. After finding the optimal edible coating material, we conducted an experiment to verify the effect of cacboxymethyl cellulose concentration. Different concentration of cacboxymethyl cellulose (1.0%, 1.5%, 2.0%, 2.5%, 3.0%) were examined. The effectiveness of edible coating was based on different values of Water activity (a_w) Elasticity (lb/in²), Astaxanthin (µg/g), *Coliform* (cfu/g), Peroxide value (mEqO₂/ kg), Thiobarbituric acid (mg malonaldehyde/ kg). All treated samples were analyzed after 12 months of storage at ambient temperature.

Physico-chemical, microbial and sensory evaluation of dried shrimp during storage

Water activity (a_w) was measured by Rotronic instrument. Elasticity (lb/in²) was measured by penetrometer. Astaxanthin (µg/g) was measured spectrophotometrically using spectrophotometer (Aline Kazumi Nakata da Solva *et al.*, 2018). *Coliform* (cfu/g) was measured by 3M-Petrifilm. Peroxide value (mEqO₂/ kg) was determined using the CDR FoodLab® instrument. Thiobarbituric acid (mg malonaldehyde/ kg) was measured by 1,1,3,3-tetraethoxypropane (Torres-Arreola *et al.*, 2007). Sensory score was assessed by a group of panelist using the 9-point hedonic scale.

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.

Result and Discussion

Effect of edible film coating to physicochemical quality, antimicrobial capacity and sensory score of dried shrimp during storage

Raw shrimps were treated with 4.0% salt, 2.0% sorbitol in 20 minutes; boiling in 1.5 minutes. After that they were dried at 55°C to 12% moisture content. After that, the dried shrimps were treated by different formulas (N₀: control; N₁: 1.0% whey protein isolate; N₂: 1.0% w/w cacboxymethyl cellulose; N₃: 1.0% w/w corn protein; N₄: 1.0% w/w gelatin). The effectiveness of edible coating was based on different values of Water activity (a_w), Elasticity (lb/in²), Astaxanthin (µg/g), *Coliform* (cfu/g), Peroxide value (mEqO₂/ kg), Thiobarbituric acid (mg malonaldehyde/ kg). All treated samples were analyzed after 12 months of storage at ambient temperature. Results revealed in table 1. From table 1, cacboxymethyl cellulose was superior to other coating material so this formula was selected for the next experiment.

Table 1 : Effect of edible film coatings to physicochemical quality, antimicrobial capacity and sensory score of dried shrimp during storage

Coating	Before storage	After 12 months of storage				
		N ₀	N ₁	N ₂	N ₃	N ₄
Water activity (a _w)	0.39±0.03 ^c	0.48±0.02 ^a	0.44±0.00 ^{ab}	0.39±0.01 ^c	0.42±0.02 ^{bc}	0.43±0.03 ^b
Elasticity (lb/in ²)	13.64±0.00 ^a	12.31±0.03 ^d	12.69±0.02 ^c	13.59±0.01 ^a	12.84±0.03 ^{bc}	12.94±0.01 ^b
Astaxanthin (µg/g)	33.81±0.02 ^a	30.24±0.01 ^c	32.17±0.03 ^d	33.79±0.00 ^a	33.44±0.02 ^b	33.17±0.00 ^c
TBARS (mg/kg)	0.14±0.01 ^d	2.48±0.01 ^a	0.36±0.01 ^b	0.16±0.01 ^d	0.25±0.01 ^c	0.31±0.00 ^{bc}
Peroxide value (mEqO ₂ / kg)	0.06±0.00 ^d	1.14±0.03 ^a	0.12±0.02 ^c	0.07±0.00 ^d	0.21±0.03 ^b	0.17±0.01 ^{bc}
Thiobarbituric acid (mg malonaldehyde/ kg)	1.04±0.01 ^d	4.12±0.03 ^a	1.27±0.00 ^c	1.05±0.02 ^d	1.43±0.01 ^b	1.35±0.02 ^{bc}
<i>Coliform</i> (cfu/g)	1.1x10 ¹ ±0.03 ^{cd}	3.7x10 ¹ ±0.00 ^a	1.4x10 ¹ ±0.01 ^c	0.5x10 ¹ ±0.03 ^d	1.8x10 ¹ ±0.02 ^b	1.5x10 ¹ ±0.01 ^{bc}
Sensory score	8.36±0.01 ^a	8.01±0.03 ^a	8.17±0.00 ^c	8.35±0.02 ^a	8.24±0.03 ^b	8.19±0.00 ^{bc}

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%). N0: control; N1: 1.0% whey protein isolate; N2: 1.0% w/w cacboxymethyl cellulose; N3: 1.0% w/w corn protein; N4: 1.0% w/w gelatin

White shrimps 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. Sugar alcohols 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 sugar alcohols significantly delayed the formation of peroxides. Regarding to thiobarbituric acid (mg malonaldehyde/ kg), there was significant differences (p<0.05) among the three treatments executed. It was suggested that a marked lipid oxidation in the muscle occurred due to the high interaction with oxygen. 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). Astaxanthin is a highly unsaturated molecule and thus, can easily be degraded by thermal or oxidative processes and lose its bioactive properties during the manufacture and storage of foods. Generally, carotenoids are found in nature as all-trans molecules in which all the double bonds are in the trans configuration (Rodriguez & Rodriguez-

Amaya, 2007). It is also well known that high temperature and light conditions may promote the isomerization to the cis forms. The cis isomers of the provitamin A carotenoids have less activity than their corresponding all-trans carotenoids (Stahl & Sies, 2003; Rodriguez & Rodriguez-Amaya, 2007). Styrofoam was seen to be the most effective packaging material for both processed whole and peeled dried shrimp (Jayasinghe *et al.*, 2006).

Effect of cacboxymethyl cellulose concentration in coating to physicochemical quality, antimicrobial capacity and sensory score of dried shrimp

Raw shrimps were treated with 4.0% salt, 2.0% sorbitol in 20 minutes; boiling in 1.5 minutes. After that they were dried at 55°C to 12% moisture content. After finding the optimal edible coating material, we conducted an experiment to verify the effect of cacboxymethyl cellulose concentration. Different concentration of cacboxymethyl cellulose (1.0%, 1.5%, 2.0%, 2.5%, 3.0%) were examined. The effectiveness of edible coating was based on different values of Water activity (a_w) Elasticity (lb/in²), Astaxanthin (µg/g), *Coliform* (cfu/g), Peroxide value (mEqO₂/ kg), Thiobarbituric acid (mg malonaldehyde/ kg). All treated samples were analyzed after 12 months of storage at ambient temperature. Results revealed in table 2. From table 2, 2.0% cacboxymethyl cellulose was adequate for coating the dried shrimp.

Table 2 : Effect of cacboxymethyl cellulose concentration (%) in coating to physicochemical quality, antimicrobial capacity and sensory score of dried shrimp during storage

Coating	Before storage	After 12 months of storage				
		1.0%	1.5%	2.0%	2.5%	3.0%
Water activity (a _w)	0.39±0.03 ^a	0.39±0.01 ^a	0.39±0.03 ^a	0.39±0.03 ^a	0.39±0.03 ^a	0.39±0.01 ^a
Elasticity (lb/in ²)	13.64±0.00 ^a	13.59±0.01 ^b	13.60±0.00 ^b	13.62±0.00 ^{ab}	13.64±0.02 ^a	13.64±0.03 ^a
Astaxanthin (µg/g)	33.81±0.02 ^a	33.79±0.00 ^b	33.79±0.02 ^b	33.79±0.01 ^b	33.81±0.01 ^a	33.81±0.02 ^a
TBARS (mg/kg)	0.14±0.01 ^b	0.16±0.01 ^a	0.16±0.02 ^a	0.16±0.03 ^a	0.14±0.00 ^b	0.14±0.01 ^b
Peroxide value (mEqO ₂ / kg)	0.06±0.00 ^b	0.07±0.00 ^b	0.07±0.01 ^a	0.07±0.00 ^a	0.06±0.01 ^b	0.06±0.02 ^b
Thiobarbituric acid (mg malonaldehyde/ kg)	1.04±0.01 ^b	1.05±0.02 ^a	1.05±0.03 ^a	1.05±0.00 ^a	1.04±0.02 ^b	1.04±0.03 ^b
<i>Coliform</i> (cfu/g)	1.1x10 ¹ ±0.03 ^a	0.5x10 ¹ ±0.03 ^b	0.4x10 ¹ ±0.02 ^{bc}	0.4x10 ¹ ±0.01 ^{bc}	0.2x10 ¹ ±0.01 ^c	0.2x10 ¹ ±0.00 ^c
Sensory score	8.36±0.01 ^a	8.35±0.02 ^a	8.35±0.0 ^a	8.36±0.00 ^a	8.36±0.02 ^a	8.36±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%).

Conclusion

Vannamei shrimp (*Litopenaeus vannamei*) is one of the shrimp varieties that are currently widely cultivated due to several advantages including among others, fast growth, ability to be cultivated in high density and relatively high market price. Edible coatings are a promising preservation technology for dried shrimp because they provide good barrier against spoilage and pathogenic microorganisms, limit the lipid oxidation. The films gas barrier properties contribute to extended shelf life because physicochemical changes, such as color, texture, and moisture, may be significantly minimized. The current research showed that 2.0% w/w carboxymethyl cellulose was appropriated for coating the dried shrimps for 12 months of storage at ambient temperature in vacuum packaging.

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