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RESEARCH ARTICLE

Efficacy of Curcumin-Chitosan-Based in Glazing of Cooked Shrimp and in Coating of Dry-salted Shrimp to Extend Product Shelf-life during Preservation

N. P. Minh[1*], P. K. Thu[2], L. T. T. Trinh[3]

1. *Faculty of Food Technology - Biotech, Dong A University, Da Nang City, Vietnam.*

2. *Mekong University, Vinh Long Province, Vietnam.*

3. *Can Tho University, Can Tho City, Vietnam.*

***Corresponding Author: N. P. Minh**

Abstract

Chitosan has a wide range of potential applications in food science. It's one of the best edible and biologically safe preservative coatings for different types of foods owing to its biochemical and biodegradable property, non toxicity, film-forming, antimicrobial action. Curcumin is one of the few promising natural products with a variety of therapeutic effects. Our present research demonstrated a new edible coating formula by combining chitosan 1.5% with different curcumin concentration (0.01%, 0.02%, 0.03%, 0. 04 %). This research was conducted from 2018 to 2019 in the scientific laboratory of Mekong University. Results revealed that the chitosan-based coating layers (1.5 %) emdeded with curcumin (0.03%) could maintain the shrimp quality in glazing of cooked frozen shrimp as well as coating of dry-salted shrimp during storage. Curcumin played an important role as antioxidant in making chitosan-based film. Nontoxic, non-pollution biodegradability, surface barrier, biocompatibility, and edibility are some benefits of edible curcumin-chitosan-based coatings over plastic bags. It has been shown that it's significantly improved the quality and increased the shelf-life of shrimp product. The improvement in the product quality is achieved through inactivation of microbial growth, reduction of lipid oxidation and enhancement of sensory characteristic.

Keywords: *Shrimp, Curcumin, Chitosan, Coating, Shelf-life, Lipid Oxidation, Microbial growth, Sensory characteristic.*

Introduction

Shrimp is one of the most important seafood products worldwide [1].Some chemical and biochemical reactions can occur in dried shrimp or even at frozen temperatures [2], including oxidative changes of lipids and proteins in the muscle, which can affect deterioration in the organoleptic and sensory quality of the product, such as odor, rancidity, dehydration, weight loss, color, and texture [3]. The use of alternative technologies, such as the addition of antioxidant compounds, is necessary. However the migration of the antioxidant to the muscle is not controlled. The use of plastic packaging containing antioxidants, which may retard lipid oxidation and protein denaturation under a controlled release of the antioxidants [4, 6].In the circumstance of limiting plastic packaging usage to protect environment, the edible coating could be considered a better approach. Chitosan have been demonstrated as an ideal material for coating different agricultural products including fruit and vegetable [7, 23] and seafood [24, 33].Antioxidants have been proven to play an important role in human health [34]. Antimicrobial films have been prepared using various organic acids (e.g., citric acid, sodium lactate, sodium diacetate, and potassium sorbate; and natural preservatives in a chitosan matrix [35, 37].Curcumin, a polyphenol, is a derivative obtained from the *Curcuma longa* with beneficial pharmaceutical functions preventing inflammation, antibacterial, anticancer activities [38, 42]. Preservation of seafood products is important to prevent the loss of this rich naturally nutritional resource

[29].In order to find an alternative to complement freezing and replace water glazing for frozen shrimp as well as coating for dry-salted shrimp, we focused on the application of curcumin-chitosan-based film in glazing of cooked shrimp and in coating of dry-salted shrimp to extend product shelf-life during preservation.

Materials and Method

Material

White shrimps (*Paneus vannamei*) were collected from Soc Trang province, Vietnam. They were washed in chlorin solution 30ppm to sanitize before processing. Raw shrimps were processed into two kinds of product: cooked frozen and dry-salted ones. For the cooked frozen shrimps, they were treated with curcumin-chitosan-based coating by glazing. For the dry-salted shrimps, they were treated with curcumin-chitosan-based coating by spraying. Lab utensils were used including digital balance, spectrophotometer, stomacher, vortex, incubator, autoclave, colony counter, micro-pipette.

Chemical agents used in this research were analytical grade including chitosan, curcumin; acetic acid; 1, 1, 3, 3-tetraethoxypropane. This research was conducted from 2018 to 2019 in the scientific laboratory of Mekong University.

Researching Procedure

Effect of Curcumin-chitosan-based Coating on the Quality of Cooked Frozen Shrimp during Storage

Chitosan 1.5% was prepared by dissolving 15g chitosan powder in 1000mL acetic acid 1.0%. There were four formula of curcumin (0.01%, 0.02%, 0.03%, 0.04%) embeded in chitosan solution 1.5% by swelling method. Cooked frozen shrimps were coated by above films at the glazing step and then monitored quality change (weight loss, total plate count, lipid oxidation, sensory score) after 12 months of preservation. Shrimps coated in chitosan 1.5% film without curcumin were used as control.

Effect of Curcumin-chitosan-based Coating on the Quality of Dry-salted Shrimp during Storage

Chitosan 1.5% was prepared by dissolving 15g chitosan powder in 1000mL acetic acid 1.0%.

There were four formula of curcumin (0.01%, 0.02%, 0.03%, 0.04%) embeded in chitosan solution 1.5%. Dry-salted shrimps were coated by above films at the coating step (before packaging) and then monitored quality change (weight loss, total plate count, lipid oxidation, sensory score) after 12 months of preservation. Shrimps coated in chitosan 1.5% film without curcumin were used as control.

Physico-chemical, Biological and Sensory Analysis

Weight loss (%) was evaluated by comparison of weight before and after preservation for 12 months.

Total plate count (cfu/g) was estimated by 3M-Petrifim. Lipid oxidation (mg malonaldehyde/kg muscle) was determined by using 10 g of muscle colorimetrically at 538 nm. A standard curve was constructed with 1, 1, 3, 3-tetraethoxypropane. Sensory score was evaluated by a group of 15 members using 9 point-Hedonic scale. All panelists were asked to evaluate overall likeness, texture and flavor.

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 Stat graphics Centurion XVI.

Result & Discussion

Effect of Curcumin-chitosan-based Coating on the Quality of Cooked Frozen Shrimp during Storage

Freezing and glazing are techniques commonly used to reduce the incidence of fish deterioration processes. Rancidity is a problem in oily fish associated primarily with frozen and dried storage. The shelf-life of frozen oily fish usually ends with the onset of rancid flavors.

Volatile secondary oxidation products derived from the breakdown of these lipid hydroperoxides are believed to lead to rancid flavors and aromas [33].Aldehydes, ketones and similar compounds are the secondary products which form as the hydroperoxides react. The reactions lead to aldehydes and other products that can be measured using the thiobarbituric acid (TBARS) test [34].In this experiment, chitosan 1.5% was prepared by dissolving 15g chitosan powder in 1000mL acetic acid 1.0%. There were four formula of curcumin (0.01%, 0.02%, 0.03%, 0.04%) embeded in chitosan solution 1.5%. Cooked frozen shrimps were coated by above films at the glazing step and then monitored quality change (weight loss, total plate count, lipid oxidation, sensory score) after 12 months of preservation. Shrimps coated in chitosan 1.5% film without curcumin were used as control. Results were elaborated in Table 1.

Table 1: Effect of curcumin concentration (%) embeded in the chitosan-based coating to the quality of cooked frozen shrimp during storage

Curcumin (%) embeded in chitosan 1.5% coating film	Weight loss (%)	Total plate count (cfu/g)	Lipid oxidation (mg malonaldehyde/ kg muscle)	Sensory score
Control	3.28±0.02[a]	$1.8x10^2$±0.01[a]	1.64±0.03[a]	6.37±0.01[c]
0.01	3.19±0.00[ab]	$1.1x10^2$ ±0.00[ab]	1.31±0.03[ab]	7.13±0.03[bc]
0.02	3.15±0.04[b]	$0.6x10^1$±0.05[b]	1.24±0.02[b]	7.69±0.03[b]
0.03	3.12±0.01[bc]	$0.3x10^1$ ±0.03[bc]	1.17±0.01[bc]	8.02±0.00[ab]
0.04	3.09±0.03[c]	$0.1x10^1$±0.02[c]	1.12±0.02[c]	8.27±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%)

One study evaluated the effect of water glazing and edible coatings of 0.5% w/v and 1.5% w/v chitosan on quality parameters of frozen fish. Both types of coatings-water glazing and chitosan coatings-were applied directly on frozen Atlantic salmon (Salmo salar) and stored for 9 months at -22 °C. Samples coated with 1.5% w/v chitosan performed better in maintaining the color of the salmon and controlling microbial contamination of frozen and thawed samples [44].Fresh blue shrimp (*Litopenaeus stylirostris*) muscle was stored with antioxidants under different conditions: ANTIDX 2% packed in bilayer flm of polyamide-low density polyethylene flm (PA-LDPE) with 2% α-tocopherol; ANTIDX 4%, packed in PA-LDPE flm with 4% α-tocopherol; and ANTIDX-GLAZED, samples stored glazed with 2% α-tocopherol.

The shrimp stored with the antioxidant showed lower lipid oxidation (0.10-0.14 vs 1.58 mgMA/kg of muscle), lost less frmness and astaxanthin content. The treatments with α-tocopherol maintained the shrimp muscle quality during frozen storage [45]. Changes in lipid structure and behavior could be responsible for the deterioration of muscle quality during frozen storage [46]. Bak et al [47]. Found a significant increase in lipid oxidation of cooked cold-water shrimp (*Pandalus borealis*) afer sixth months of frozen storage with atmospheric air, while the shrimp packaged in modifed atmospheres showed no significant differences afer the same period. Moreover, Tseng et al [48].Found no differences in thiobarbituric acid (TBARS) of Australian river crab (*Cherax quadricarinatus*) treated with propyl gallate, α-tocopherol and rosemary extract as antioxidant solutions over the storage period of three months. Rodriguez-Turienzo et al [43].Indicated that whey protein based coatings delayed lipid oxidation of salmon fillets measured using both peroxide values and TBARS.

Effect of Curcumin-chitosan-based Coating on the Quality of Dry-salted Shrimp during Storage

In this experiment, chitosan 1.5% was prepared by dissolving 15g chitosan powder in 1000mL acetic acid 1.0%. There were four formula of curcumin (0.01%, 0.02%, 0.03%, 0.04%) embeded in chitosan solution 1.5%. Dry-salted shrimps were coated by above films at the coating step (before packaging) and then monitored quality change (weight loss, total plate count, lipid oxidation, sensory score) after 12 months of preservation. Shrimps coated in chitosan 1.5% film without curcumin were used as control. Results were depicted in Table 2.

Table 2: Effect of curcumin concentration (%) embeded in the chitosan-based coating to the quality of dry-salted shrimp during storage

Curcumin (%) embeded in chitosan 1.5% coating film	Weight loss (%)	Total plate count (cfu/g)	Lipid oxidation (mg malonaldehyde/ kg muscle)	Sensory score
Control	1.46±0.03[a]	3.9×10^2 ±0.03[a]	3.78±0.03[a]	7.12±0.03[c]
0.01	1.32±0.03[b]	2.1×10^2±0.01[ab]	1.38±0.01[b]	7.86±0.04[b]
0.02	1.30±0.01[bc]	1.4×10^2±0.04[b]	1.14±0.00[bc]	8.03±0.02[ab]
0.03	1.29±0.02[bc]	8.1×10^1±0.02[c]	1.02±0.02[bc]	8.27±0.01[a]
0.04	1.26±0.01[c]	7.8×10^1±0.00[c]	0.97±0.01[c]	8.30±0.00[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%)

Acceptance of frozen shrimp depends on its color, which is considered one of the most important sensory attributes [49]. The effect of chitosan-based edible coatings containing garlic (Allium sativum) oil at 0.5, 1.0 and 1.5% on shrimp (*Parapenaeus longirostris*) quality was evaluated during refrigerated storage by Asik and Candogan [50]. A minimum concentration of garlic oil (0.5%) in the chitosan coating was sufficient to prolong the shelf-life [50]. One study explored the in situ fabrication of chitosan-poly (vinyl alcohol)-silver nanocomposite films in view of their increasing applications as antimicrobial packaging, wound dressing and antibacterial materials.

The anti-microbial and anti-fungal activity of the chito-san-PVA silver nanoparticle films have demonstrated significant effects against Escherichia coli (E. coli), Pseudomonas, Staphylococcus, Micrococcus, Candida albicans, and Pseudomonas aeruginosa (P. aeruginosa) [51]. Novel smart films for seafood freshness monitoring were developed by incorporating curcumin (Cur) into a chitosan (CS)/oxidized chitin nanocrystal (O-ChNCs) matrix. O-ChNCs (200-400 nm in length) were prepared from chitin by 2, 2, 6, 6-tetramethylpiperidine-1-oxylradical (TEMPO)-oxidation method and used as reinforcement filler for smart films. The effects of O-ChNCs or Cur addition on the structural, mechanical, barrier and optical properties of Cur/CS/O-ChNCs (Cur-CN) films were investigated. It was found that the incorporation of O-ChNCs and Cur could significantly alter the mechanical, barrier and optical properties of the films. The Cur-CN films showed better barrier properties against water vapor and UV-vis light as well as higher mechanical strength than CS film. Among all the films tested, Cur-CN film containing 10 wt % of O-ChNCs (w/w, CS and O-ChNCs basis) presented the best performance [52, 53].

Conclusion

Shrimp products have a short shelf-life. During storage many reactions occur leading to changes in quality such as endogenous chemical and enzymatic reactions. It was possible to use curcumin-chitosan-based coating to maintain product shelf-life of cooked frozen shrimp as well as dry-salted shrimp. Curcumin-chitosan-based coatings can improve the quality of dried and frozen products by retarding microbial growth, reducing lipid oxidation and moisture loss, and functioning as a carrier of antimicrobial and antioxidant agent. This biodegradable edible coating has various advantages over synthetic coatings such as being edible and generally being more environmentally friendly.

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