Effect of Cinnamon Oil and Garlic Extract for Fresh Shrimp Preservation

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Abstract:

The effect of garlic extract, cinnamon oil on the quality changes of raw shrimp during refrigerated storage (4±1°C) of 15 days was investigated. Four different treatments were treated : control sample (T1), 8 % garlic extract solution (T2), 0.5 % cinnamon oil (T3) and 8% garlic extract incorporated with 0.5% cinnamon oil (T4). The results indicated that the cinnamon oil incorporated with garlic extract (T4) was efficient against the proliferation of microorganisms including total variable count. The results from chemical analysis indicated that the treated samples underwent a significant decrease ($P \leq 0.05$) in the term of pH value and the total volatile base nitrogen content. However, the results of sensory attributes show that the high scores for the appearance, texture and odor demonstrated that 8% garlic extract incorporated with 0.5% cinnamon oil (T4) can help delay the proliferation of microorganisms spoilage, prevent the generation of undesirable chemicals, improve the levels of sensory attributes and extend the shelf life of raw shrimp during refrigerated storage. The samples treated with 8% garlic extract incorporated with 0.5% cinnamon oil (T4) had lowered change in chemical quality but similar total bacteria count, in comparison with T3, T2 and T1. Therefore, 8% garlic extract incorporated with 0.5% cinnamon oil (T4) could be a promising inhibition of raw shrimp quality loss with extended shelf life. While the use of cinnamon oil (T3) extended the shelf life of raw shrimp by 12 days, T3 for 9 days, compared to 6 days in T1 and T2 samples.

Keywords: Shrimp, Total volatile base nitrogen, Shelf life, Cinnamon oil, Garlic extract

Introduction

Shrimp is one of the popular seafoods in the world including East Asian countries such as Thailand, Korea, China, and Japan, because it has several applications in foods. However, seafood quality is easily lost due to microbiological contamination and/or chemical reactions because shrimp has high water content, large quantities of free amino acids, and autolytic enzymes among other factors [1]. After the capture of shrimp, a series of complex changes occurs in the seafood, resulting in a decrease of quality [2]. Therefore, shrimp should be frozen or kept at a cold temperature to limit or reduce enzymatic and microbial activities to keep its good quality [3]. Also, other treatments such as dipping or spraying food additives are being developed. To reduce the undesirable biochemical and physical changes, the kinds of food additives for dipping solutions in seafood are sodium acetate, sodium lactate, sodium citrate. [4] Although phosphate derivatives are commonly used among other additives, only a few researchers have studied the effects of phosphate derivatives in shrimp. Consumer perceive fresh seafood to be a superior product to its frozen equivalent. Being highly perishable, fresh seafood had a limited shelf life due to their biological composition. Spoilage of shrimp results from the oxidation of microorganism. Even if refrigeration can be applied to the products, these activity although slower, will over time lead to a shorter shelf life and a poorer safety and quality of shrimp products and consequently represent a high risk for consumer health and economic losses, therefore enhancing shelf life of shrimp with natural preservatives is an important issue to eliminate economic losses and provide safe and good quality seafood to consumer. Cinnamon oil is the natural preservative and flavoring agent that is not toxic when it is added in food products. It can inhibit the growth of *Aspergillus flavus, Aspergillus parasiticus, Fusarium moniliforme* [5], *Lactobacillus* sp., *Bacillus*

thermoacidurans, *Salmonella* sp., *Corynebacterium michiganense*, *Pseudomonas striafaciens*, *Clostridium botulinum and Penicillium roqueforti* [6]. Cinnamon oil and thyme oils are active against *Salmonella enterica*, *Escherichia coli*, *Staphylococcus aureus and Listeria monocytogenes* [7]. Therefore, cinnamon oil should be examined with respect to antimicrobial modifying activity. The most important cause of the raw shrimp spoilage are accumulation of undesirable compounds as a resulted of microbiological growth and biochemical reaction. Alginates are naturally occurring, indigestible polysaccharides commonly produced by and refined from various genera of brown algae . Alginate is widely used in various industries such as food, beverage, textile, printing, and pharmaceutical as a thickening agent, stabilizer, emulsifier, chelating agent, encapsulation, swelling, a suspending agent, or used to form gels, films, and membrane. Sodium alginate is the most common salt of alginate [8]. Application of edible film and coating with natural active compounds for enhancing storage stability of food product is a promising active packaging approach. Several biopolymers with the inclusion of antimicrobial and/or antioxidant active agent have been test in vitro. In this study, alginate coating with the inclusion of cinnamon oil or garlic extract were applied to raw shrimp as an alternative natural method to extend shelf life and prevent the quality change in during storage.

Materials and methods

Material

Five kg middle size (80-95 shrimp/kg) of Vannamei shrimp (*Litopenaeus vannamei*) were purchased from a shrimp farm in Trang province, Thailand and transported to laboratory in ice-packed container immediately after being caught. Upon After arriving to the laboratory shrimp sample were immediately weighed and washing with tap water. The shrimp samples were de-headed, peeled, and deveined. The samples were divided into four equal groups and stored in refrigeration until further treatments. Cinnamon oil and garlic extract prepared by Specialty Natural Products Co.,Ltd.

Method

Preparation of sample : Four factors were treats. Dipping treatments of shrimp batch was soaked for 3 mins in different four of cold solutions (4±1°C), The first one was dipped into distilled water (T1). The second one was dipped into alginate solution (20 µg ml^{-1} incorporated with 8% garlic extract (T2). The third was dipped into alginate solution (20 µg ml^{-1} incorporated with 0.5% cinnamon oil (T3). Then, the fourth one was dipped into alginate solution (20 µg ml^{-1}) incorporated with 0.5% cinnamon oil and 8% garlic extract (T4). Then sample remove from the treatment solutions with a strainer (drained well for 1 min) prior to packed into sterile bags.

Packaging and storage: Shrimp samples were packed in sterile bags with 250 g. in each bag, three bags for each groups) and stored in the refigerator (model Evermed, LR 625 WV.201) at 4±1°C. The sample were analysed to microbiological, physiological and sensory properties at day zero, then periodically every 3 days until decomposition or up to 15 days of refrigerated storage.

Microbiological examination: The samples were taken aseptically in a vertical laminar-flow cabinet (Alpha Clean, Model 1300) and 25 g of shrimp were transferred to a stomacher bag, 225 ml of sterile Butterfield's phosphate-buffered water (Difco) using a stomacher machine (Lab-blender 400, Seward Laboratory) for 60 sec. From the 10^{-1} dilution, other decimal dilutions were prepared. Total viable count (TVC) were determined by using pour plate method. [9] Plate count agar (Difco) were used and incubated at 35°C for 48 hours (Blender, model 28). The permissible limit of TVC in chilled fish was 6 log CFU g^{-1} recommended by ICMSF. [10]

Chemical analyses: The total volatile basic nitrogen (TVB-N) expressed as mg TVB-N per 100 g muscle of shrimp meat was determined according to the method of Conway's diffusion method [11]. For pH determination 10 g of shrimp samples were homogenized in 100 ml distilled water for 1 min by homogenizer and pH value were measured at room temperature using pH meter (SI Analytics, model lab 855) as described by Ozyurt *et al* [12]. The pH values above 7.10 are indicative of decomposition in fish [12].

Sensory assessment of raw shrimp: Scoring method with 10 trained panel was carried using 4-point scoring scale, according to National Bureau of Agricultural Commodity and Food Standard of Thailand, ACTF [13]. The samples served to the panellist to evaluate the appearance, odor and texture attributes of

shrimps. Three parameters on a scale from 1 (extremely undesirable) to 4 (extremely desirable) were evaluated. They were asked to give a score for each of appearance, odor and texture while the samples were raw.

Statistical analysis results were expressed means and standard deviation (Means±SD) from triplicate. Analysis of variance (ANOVA) was performed to compare the effect of dipping treatments. Differences among the mean values of the various treatments and storage periods were determined by Duncan new multiple rang test (DMRT) and Significant differences were defined as $p \leq 0.05$, according to program package.

Results and discussion

Microbiological examination

Total viable count (TVC) of shrimp under investigation were analysed and log CFU g^{-1} were present in Table 1, which slight higher in TVC was showed in control samples when compared with other treatment at day zero, indicating that cinnamon oil and garlic extract caused sudden lethal effect for microorganism immediately after dipping process. TVC of raw shrimp samples steadily increased as the of cold storage progressed, TVC of T1 showed the highest number. According to the permissible limit of TVC in chilled fish was 6 log CFU g^{-1} recommended by ICMSF [10], from the Table 1 showed that sample of control (T1) exceeded such limit at 6 day, while the sample of T2, T3 and T4 exceeded such limit at 6, 9 and 12 day respectively. Various studies have shown that garlic is also effective against many gram-negative and gram-positive bacteria, such as *Escherichia coli*, *Salmonella*, *Staphylococcus* and *Vibrio chlorelae*. Many of these bacteria do not develop resistance to allicin, despite being resistant to antibiotics. [14] [15] One study demonstrated the potential for garlic to act as a meat preservative. Garlic extract was shown to kill about 75% of the *E. coli* and non-pathogenic Salmonella on chicken meat as well as a majority of the contaminating bacteria on the meat after 10 minutes of exposure. The study also showed that the garlic extract could limit the growth of all the bacteria tested. [16]

Cinnamon showed as antibacterial properties against gram positive and gram negative bacteria. Also, agree with Irfiana *et al*. [17] who recorded that cinnamon oil showed decreasing count of total plat count microorganisms of vaccum packed ground beef during refrigerated storage at 4±1°C for 0, 3, 6, 9,12 and 15 day when compared with count of control samples, due to cinnamon contains active compounds such as polyphenols, cinnamaldehyde and antibacterial compounds.

Table 1 Changes in total viable count of shrimp stored at refrigerated temperature (4±1°C)

Days	CFU/g			
	Control (T1)	**8% garlic extract (T2)**	**0.5% cinnamon oil (T3)**	**8%garlic extract+0.5% cinnamon oil (T4)**
0	2.4×10^7	2.5×10^6	6.8×10^5	8.3×10^5
3	6.7×10^7	3.4×10^6	2.9×10^5	5.4×10^5
6	2.1×10^6	9.6×10^6	8.6×10^5	2.6×10^4
9	4.5×10^6	3.3×10^6	4.1×10^4	4.8×10^4
12	6.0×10^6	1.4×10^5	3.4×10^4	3.5×10^3
15	3.5×10^5	2.8×10^4	4.4×10^4	8.8×10^3

Chemical examination

TVB changes

The initial (day-0) TVB-N value of T1, T2, T3 and T4 was 5.93, 3.60, 4.10 and 2.80 mgN/100g, respectively (Table 2). It showed that TVB-N of all samples increased with different rates, depending on pre-treatment and time of storage. The lowest TVB-N was obtained from T4 followed by T3, T2 and T1 during storage period, respectively. The TVB-N, which is mainly composed of ammonia and primary, secondary and tertiary amines, resulted from degradation of proteins and non- protein nitrogenous compounds is well documented as a good index for the quality and shelf life of fish and fish products because its increase is related to spoilage by the activity of endogenous enzymes and bacterial growth. The TVB-N values of good quality fish are generally less 25 mg N/100 g muscle and above 25-30 mg TVB/100 g indicated that fish is decomposed and inedible [18]. Generally, when the TVB-N level exceeded the maximum value, samples were already refused by the panelists. Therefore, TVB-N values correlated well with the results of sensory analyses and microbiological examination, providing a good index for the assessment of freshness of raw shrimp during refrigerated storage.

pH changes

Table 3 shows pH values for raw sample fillet as a function of treatment and storage time at 4±1°C. Initial (day 0) pH value in fresh control fillet samples (T1) was 6.30. While T2 and T3 were 6.05 and 5.15 were observed. In contrast, cinnamon oil treated-sample (T4) exhibited the lowest pH values as compared with other sample. Our results (Table 3) further shows that during cold storage, pH of raw shrimp samples increased throughout the storage time, presumably due to the production of basic amines as a result of decomposition of nitrogenous compounds caused primarily by microbial activity. Such an increase in pH of fish could indicate bacterial growth, the reduction of quality and ultimately spoilage of fish [12][19]. The sharp increase was observed in pH of control samples to end day of storage. The pH of 8% garlic extract (T2), 0.5% cinnamon oil (T3) and 8%garlic extract+4% cinnamon oil (T4) treated samples was quite increased throughout the storage.

Table 2 Changes in total volatile base nitrogen (TVB-N) of shrimp stored at refrigerated temperature (4±1°C)

Days	TVB-N (mg/100)			
	Control (T1)	**8% garlic extract (T2)**	**0.5% cinnamon oil (T3)**	**8%garlic extract+0.5% cinnamon oil (T4)**
0	5.93±0.45^{a}	3.60±1.98^{b}	4.10±0.65^{b}	2.80±1.05^{c}
3	12.07±0.56^{a}	5.93±0.76^{b}	3.60±1.45^{c}	2.36±0.54^{c}
6	16.23±0.58^{a}	11.52±0.56^{a}	5.72±0.76^{b}	4.23±0.78^{b}
9	25.00±0.78^{a}	15.08±1.45^{b}	4.59±0.80^{c}	4.54±0.61^{c}
12	43.47±0.45^{a}	23.19±0.87^{a}	13.64±0.69^{b}	11.58±0.98^{b}
15	50.35±1.21^{a}	37.01±0.65^{b}	29.77±0.34^{b}	29.05±0.32^{b}

Means followed by a different letter within each comparative category in a row are significantly different P□0.05).

According to in Table 3, it is obvious that starting from the third day of cold storage control samples exhibit significantly higher ($p \leq 0.05$) pH values than treated samples, conversely, T4 treatments had the lowest pH increment during the course of refrigerated storage. No significant differences ($P > 0.05$) were noticed between pH values of T3 and T4 treated samples. Table3 also obvious that control raw shrimp were of good and acceptable quality with regard to pH value up to 6 days in comparison to 9 and 12 days noticed for T3 and T4 treated samples, respectively. In addition, T4 samples reached the critical pH value (7.19) at 15 day of refrigerated storage. These results are in accordance with that found by [12] who reported that pH values above 7.10 are indicative of decomposition in fish.

Table 3 Changes in pH of shrimp stored at refrigerated temperature (4±1°C)

Days	Control (T1)	8% garlic extract (T2)	0.5% cinnamon oil (T3)	8%garlic extract+0.5% cinnamon oil (T4)
0	6.30±0.00[a]	6.05±0.00[a]	5.15±0.01[b]	5.06±0.01[b]
3	6.52±0.00[a]	6.60±0.00[a]	6.40±0.01[a]	5.81±0.02[b]
6	6.99±0.00[a]	7.08±0.00[a]	6.70±0.02[a]	6.18±0.02[b]
9[ns]	7.48±0.00	7.42±0.00	6.98±0.00	6.95±0.01
12	8.20±0.00[a]	8.05±0.01[a]	7.15±0.00[b]	7.08±0.01[b]
15	8.50±0.00[a]	8.35±0.01[a]	7.28±0.01[b]	7.19±0.01[b]

Means followed by a different letter within each comparative category in a row are significantly different (P□0.05)

Sensory evaluation

Changes in the sensory attribute scores of raw control and treated raw shrimp samples during refrigerated storage at 4±1°C are depicted in Table 4. Fresh shrimp were generally considered to possess very high acceptability. All samples developed a fishy odor as the storage time increased with significantly differences (P≤0.05) between treatments (Table 4). For the control samples (T1), the deterioration occurred after 6 days of storage as evidenced by strong fishy and putrid odor. Also, the deterioration in color occurred after 6 days during storage at 4±1°C. The treatment of T2, T3 and T4 exhibited higher scores (P≤0.05) for odor and color and exhibited no negative effect on sensory characteristics during storage as compared with control samples. For each batches, extended shelf life of raw shrimp to 6, 9 and 12 days, respectively was observed. Results of Table 4 also indicate that immersing samples in cold solution containing 0.5% cinnamon incorporated with 8%garlic extract (T4) prior to air packaging and refrigeration process effectively retarded off-odor, maintained good color and extended the shelf life of raw shrimp samples to 12 days with the highest sensory scores (P≤0.05) and pleasant herbal flavor. Similar trend of raw shrimp shelf life was achieved during refrigerated storage by other authors [20][21]. However, the protective effects of garlic extract and cinnamon oil reflect strong antimicrobial activities of such natural materials. While, undesired off-odors and flavors, color changes, slime formation and texture deterioration occurring during fillet spoilage are mainly caused by products of bacterial growth and metabolism. The present results indicate that sensory scores correlated well with the increase in TVB-N values and microbiological counts of the same samples.

Table 4 Changes in appearance odor and texture score of shrimp stored at refrigerated temperature (4±1°C)

Quality	days	Control (T1)	8% garlic extract (T2)	0.5% cinnamon oil (T3)	8%garlic extract+0.5% cinnamon oil (T4)
appearance	0[ns]	4.0±0.05	3.8±0.03	3.7±0.09	4.2±0.09[a]
	3	2.3±0.30[c]	3.3±0.05[b]	3.2±0.79[b]	4.1±0.03[a]
	6	2.3±0.67[c]	3.2±0.63[b]	3.3±0.67[b]	4.0±0.63[a]
	9	2.1±0.20[c]	3.0±0.67[b]	2.5±0.71[c]	3.4±0.70[a]
	12	1.4±0.57[c]	2.3±0.67[b]	2.0±0.00[c]	2.8±0.23[a]
	15	1.0±0.00[b]	1.0±0.00[b]	1.0±0.00[b]	1.6±0.52[a]
odor	0	3.5±0.05[a]	3.5±0.57[a]	3.2±0.52[b]	3.3±0.82[b]
	3	2.5±0.09[b]	3.0±0.47[a]	3.0±0.82[a]	2.9±0.57[b]
	6	1.8±0.08[b]	2.8±0.16[a]	2.7±0.94[a]	2.8±0.18[a]
	9	1.4±0.52[c]	2.2±0.53[b]	2.3±0.95[b]	2.9±0.00[a]
	12	1.4±0.52[b]	1.00±0.42[b]	2.0±0.52[a]	2.2±0.84[a]
	15	1.0±0.00[b]	1.0±0.00[b]	1.6±0.00[a]	1.6±0.52[a]
texture	0[ns]	3.4±0.79	4.0±0.82	4.2±0.52	4.3±0.74

3	3.0±0.48^{b}	3.7±0.79^{a}	3.4±0.57^{a}	3.8±0.79^{a}
6	2.3±0.40^{a}	3.0±0.32 ^{a}	3.1±0.57^{a}	3.0±0.10 ^{a}
9	1.4±0.42^{c}	2.3±0.67^{b}	2.4±0.70^{b}	3.0±0.50 ^{a}
12	1.2±0.00^{c}	2.0±0.52^{b}	2.4±0.00^{ab}	2.5±0.52 ^{a}
15	1.0±0.00^{b}	1.0±0.00^{b}	1.0±0.00^{b}	1.6±0.09 ^{a}

Means followed by a different letter within each comparative category in a row are significantly different (P□0.05).

Conclusions

This study demonstrated that dipping of raw shrimp in cinnamon oil and garlic solution could be prolong the shelf life and quality of samples. The resulted showed slower change in qualities of raw shrimp when compared with the control and the sample garlic extraction alone. Considering from microbiological and sensory quality, it was found that raw shrimp, dipped into cinnamon oil and garlic solution could be accepted at less than 12 days at refrigerated temperature storage whereas control samples were accepted in 6 days.

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References

[1] Fang X.B., Sun H.Y., Huang B.Y., and Yuan G.F. Effect of pomegranate peel extract on the melanosis of Pacific white shrimp (*Litopenaeus vannamei*) during iced storage. J. Food Agric.Environ. 2013;11:105-109.

[2] Tsironi T., Dermesonlouoglou E., Giannakourou M., and Taoukis P. Shelf life modelling of frozen shrimp at variable temperature conditions. LWT-Food Sci Technol. 2009; 42 : 664-671.

[3] Gonçalves A.A., Ribeiro J. and L.D. Do. Phosphates improve the seafood quality? Reality and legislation. Pan-Am J. Aquat. Sci. 2008;3:237-247

[4] Sallam K.I. Antimicrobial and antioxidant effects of sodium acetate, sodium lactate, and sodium citrate in refrigerated sliced salmon. Food Control.; 2007;18:566-575.

[5] Soliman K.M., and R.I. Badeaa: Food Chem Toxicol. Vol.40, 2002; p.1669-1675

[6] Matan, N., H. Rimkeeree, and A.J. Mawson : Int. J. Food Microbiol. Vol. 107, 2006; p.180-185

[7] Smith-Palmer,A., J., Stewart and L., Fyfe: Lett. App.l Microbiol. Vol.26, 1998; p.118-122.

[8] Kim Y.J., Yoon K.J., and Ko S.W. Preparation and properties of alginate superabsorbent filament fibers crosslinked with glutaraldehyde. J. Appl. Polym. Sci. 2000;78:1797-1804

[9] BAM. Bacteriological Analytical Manual Chapter 3 Aerobic Plate Count. Food and Drug Administation, US, 2001.

[10] ICMSF. Microorganisms in Foods, Sampling for Microbiological Analysis : Principles and Specific Applications. 2nd Edn.,University of Toronto Press, Toronto, 1986.

[11] Conway, E.J. Microdiffusion analysis and volumetric error. 5th ed., Crosby Lockwood and Son Ltd, London. 467 p. 1962.

[12] Ozyurt, G., E.,Kuley, S. Ozkutuk and F. Ozogul. Sensory, microbiological and chemical assessment of the freshness of red mullet (*Mullus barbatus*) and goatfish (*Upeneus moluccensis*) during storage in ice. Food Chemistry, 2012; 114:505-510.

[13] National Bureau of Agricultural Commodity and Food Standard of Thailand. Thai Agricultural .commodity and Food Standard TACFS 7020-2007 (Vannamei Shrimp). 2007.

[14] Waag, T., Gelhaus, C., Rath, J., Stich, A., Leippe, M., and Schirmeister, T. Allicin and derivaates are cysteine protease inhibitors with antiparasitic activitiy. Bioorg Med Chem Lett., 2010; 20, 5541-5543.

[15] Strika, I.A, Basic, A.B, and Halilovic, N.B . Antimicrobial effects of garlic (*Allium sativum* L.). Bulletin of the Chemists and Technologists of Bosnia and Herzegovina. 2017; 70 (1) : 24-29.

[16] Sarma N. Can Garlic (*Allium sativum*) Be Used as a Meat Preservative. Kansas Academy of Science Vol. 107 No. ¾ (Autumn, 2001) :2004; pp. 148-154.

[17] Irfiana D, Utami R, Khasanah L.U. and Manuhara GJ. Preservation effect of two-stage cinnamon Bark (*Cinnamomum burmanii*) oleoresin microcapsules on vacuum-packed ground beef during refrigerated storage. International Conference On Food Science and Engineering 2016;1-7.

[18] Connel, J.J. Control of fish quality. Fishing News Books. Farnham, Surrey. 179 p, 1975.

[19] Gram, L. and Huss, H.H. Microbiological spoilage of fish and fish products. International Journal of Food Microbiology, 1986; 33, 121-137.

[20] Burt, S. Essential oils: their antibacterial properties and potential applications in foods-a review. International Journal of Food Microbiology, 2004; 94, 223–253.

[21] Erkan, N., H. Dogruyol, A. Gunlu and I. Genc, Use of natural preservatives in seafood: Plant extracts, edible film and coating. Journal of Food and Health Science, 2015; 33-49.