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Effect of Chitosan Incorporated with Natural Oils on Physicochemical Properties of Ready-to-Eat Shrimp

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Abstract: Ready-to-eat (RTE) shrimp is a highly perishable aquatic animal with short shelf-life. The chitosan edible coatings have been found for having the great antimicrobial properties for food protection and preservation. However, their uses are currently limited owing to their hydrophilic character and weak water resistance. Thus, to improve water-barrier properties of chitosan coating and extend the shelf-life of RTE shrimp by minimizing the deterioration, the hydrophobic compounds (lipids), such as lemon and olive oils were incorporated in the chitosan coating. Initially, the shrimps were cooked in boiling water for 2 minutes until it reached a temperature of 63°C. Then, RTE shrimps were dipped in chitosan solution mixed with lemon or olive oils for 5 mins and stored at 6±1 ºC for 14 days. The viability of the coating was assessed by evaluating pH, color and texture of the treated samples during the storage period. Chitosan edible coating incorporated with lemon oil (CL) had a better outcome on pH, color and texture as compared to control sample (C) and chitosan coating incorporated with olive oil (CO) ($p<0.05$). The result shows that the natural essential oil improved the performance of chitosan coating in extending the quality of RTE shrimp.

Keywords: Ready-To-Eat Shrimp, Chitosan Coating, Lemon Essential Oil, Olive Oil, Physicochemical Properties

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1. Introduction

Chitosan, the second most common polysaccharide in nature, is a linear polymer made up of (1-4)-linked 2-amino-deoxy-D-glucopyranose [1]. The antimicrobial properties of chitosan against a range of bacteria and fungi have also been thoroughly documented [2][3][4]. The glucosamine monomer is more sensitive to antimicrobial activity compared to chitin because its positive charge on C-2 is lower than pH 6, which enables its usage in a range of fields, including food science, contributes to this exceptional quality. Since chitosan is an edible material, it has gainedfavor as an antimicrobial edible coating for fresh and processed foods as a result [5]. In addition, the researchers have concentrated on novel natural processes or materials in response to consumer demandfor healthier products. Because they may prolong the shelf life of RTE food products, edible coatings have recently drawn more interest [6].

The chitosan has film-forming abilities, which has a potential as coating for maintaining the aesthetic appeal of ready-to-eat food products. Natural oils are common substances that can be incorporated with the chitosan solution, such as lemon [7], rosemary [8], and cinnamon essential oils [9]. The addition of essential oils to the polysaccharide solution prolonged the shelf life of the food [7-9]. For ready-to-eat (RTE) foods like shrimp, storage in a refrigeration condition is required to ensure the quality and safety of the product. However, recontamination with bacteria after processing may enhance the quality deterioration of the RTE shrimp during storage [10]. A recent study has employed chitosan solution as edible coating on RTE shrimp was provided strong evidence that the treatment was promising towards shelf life extension of the product [10].

The hydrophilic nature and lower water resistance restrict the use of chitosan for coating. Incorporation of natural oils with chitosan can enhance the water-vapor barrier capabilities of the coating [5]. Therefore, this study aims to investigate the effectiveness of lemon essential oil and olive oil incorporated with chitosan as coating for RTE shrimp.

2. Materials and Methods

2.1 Materials

Chitosan powder (CAS No: 9012-76-4), frozen shrimp, lemon essential oil and olive oil were purchased from a local supplier (Johor, Malaysia). Glacial acetic acid and distilled water were obtained from laboratory of University of Tun Hussien Onn Malaysia (Pagoh).

2.2 Preparation of Chitosan Solution

1% (w/v) chitosan solution was prepared by mixing 10 g of chitosan powder with 1000 ml of distilled water and stirring for 10 minutes using FAVORIT Stirring Hotplate. Then 10 ml of glacial acetic acid was added to the mixture and stirring for an hour at 40 °C [11].

2.3 Preparation of Chitosan Solution Incorporated with Lemon Essential Oil and Olive Oil

10 ml of lemon essential oil was added and mixed with 1% (w/v) of chitosan solution to prepared 1% (v/v) of chitosan solution with lemon essential oil [12]. Other than that, 10 ml of olive oil was added and mixed with 1% (w/v) of chitosan solution to prepare 1% (v/v) of chitosan solution with olive oil [13].

2.4 Preparation of Ready-To-Eat (RTE) Shrimp

The preparation of RTE shrimp was prepared according to Chen et al. [14] with slightly modification. The frozen beheaded, peeled, and deveined shrimp were brought to the lab after purchased and stored in the freezer (-23°C) for further usage. The RTE shrimp (weighing around ± 5g a piece) were packaged in the zip lock bag. Before each experiment, the frozen shrimp requires thawing for overnight at 4 °C in the chiller. After that, the shrimps were cooked in boiling water for 2 minutes until it reached a temperature of 63°C in the center of the shrimp meat [10].

2.5 Preparation of Chitosan Edible Coating Incorporated with Lemon Essential Oil and Olive Oil on RTE Shrimp

The RTE shrimp were randomly assigned to one of three coating groups: chitosan (C), chitosan incorporated with lemon essential oil (CL), or chitosan incorporated with olive oil (CO). The RTE shrimp were coated with chitosan for five minutes using solutions containing 1.0% (w/v) and 1.0% (v/v) CL and CO. A method given by Aşik et al. [15] and Chen et al. [14] with a small modification of the methodology was used to evaluate the application of a chitosan edible coating combined with lemon essential oil and olive oil on ready-to-eat shrimp. The shrimp with various coatings were repackaged in a spherical plastic container and chilled (6°C) for 14 days, with samples being analyzed on day 0, 2, 7, 10, and 14.

2.6 Physicochemical Properties

2.6.1 pH

The value of pH was measured in triplicate by blending 10 g of samplewith 100 mL of distilled water for 1 min in a Panasonic blender, and then measuring the slurries' pH ateach sampling interval throughout the storage period with an Oakton pH meter [15].

2.6.2 Color

The individual sample cups with an opaque color were filled with shrimp meat [16]. A color spectrophotometer (MiniScan EZ HunterLab) was calibrated prior measurement. L* had a brightness scale from 0 (dark) to 100 (bright) (white). The a* indicates the red or green coordinate and b* indicates values for yellow or blue.

2.6.3 Texture

According to Li et al. [17], the hardness and springiness of RTE shrimp were measured using a texture analyzer (TA-XT PLUS Stable Micro Systems, Surrey, England, UK). A cylinder probe with 36 mm radius (P/36R) was used for the measurement. In a brief, the samples were measured at room temperature using the following parameters: distance = 5.00 mm, hold period = 60 sec, trigger = 5.0 g; crosshead pre-test, test, and post-test speeds are 1 mm/s, 1 mm/s, and 10 mm/s.

2.7 Statistical Analysis

All the data were analyzed using the SPSS Trial Version (17) for Windows (SPSS, Chicago, IL). The significance of the main effects was determined using one-way ANOVA by Duncan's Multiple Range Test to determine the significant differences ($p<0.05$) between the means [16]. Data from three independent replications are presented as mean ± standard deviation.

3. Results and Discussion

3.1 Physicochemical properties

3.1.1 pH

Following the results in Table 1, the initial pH of the sample was in the range of 6.0 to 6.3. The pH of all samples increased throughout the storage period, mainly on the sample treated with chitosan. The pH values of coated shrimp were increased gradually during storage, eventually reaching a range of 6.66 to 6.87 on day 14. The quality of the sample during storage is adversely affected by an increase in pH value. It is because the protein breakdown by microbial growth during storage caused a modest increase in the pH level of shrimp [15][18].

3.1.2 Color

The quality of shrimp can be determined by its color, making it an essential food characteristic. The brightness level of coated RTE shrimp tends to decline statistically ($p<0.05$) during storage, as shown in Table 1. Compared to samples of RTE shrimp coated with CL on day 7, the brightness level of shrimp coated with C and CO tends to decline very quickly. At the end of the storage day, or day 14, the L * value in RTE shrimp coated with C was 88.23 and reduced to 62.08, while the L * value of RTE shrimp coated with CL had initial value of 85.00 was reduced to 67.41, and the sample treated with CO had reduced to 63.32. When stored, RTE shrimp samples coated with CL were brighter than those coated with C and CO. This served as evidence that the combination of chitosan and lemon essential oil can effectively halt the deterioration and blackening of RTE shrimp. The L* value thus demonstrates the decrease in shrimp samples. It's because at that very moment, a black spot starts to develop on the shrimp's belly. The onset of degradation is marked by the appearance of black spots on shrimp. Additionally, shrimp experience deterioration, making them unfit for consumption [19].

The redness value (a*) of RTE shrimp was reduced during storage. Compared to samples of RTE shrimp coated with CL, samples of RTE shrimp coated with C and CO tended to lose value relatively quickly. The a* value of the sample of RTE shrimp coated with C decreased from 13.63 to 6.21, whereasthe values for the samples of RTE shrimp coated with CL and CO decreased from 13.44 to 10.66 and 12.89 to 7.24, respectively. The period of storage was causing the value of a* to decrease. The color of RTE shrimp was changed from red to opaque when being stored. The condition was brought on by an oxidation of the red pigment astaxanthin, which resulted in the loss of the red color that was one of astaxanthin's degradation features [19]. In comparison to RTE shrimps coated with CL and CO, the value of greenness (b*) of the C-coated RTE shrimp tended to decline very quickly on day 14. The b* values of RTE shrimp coated with C, CL and CO were decreased to 8.01, 8.99 and 8.36, respectively. In conclusion, the samples were getting darker and vivid in color due to the increased oxygen level during storage.

3.1.3 Texture

Table 1 shows the hardness of RTE shrimp samples that were coated with C, CL and CO gradually decreased from day 2 until day 7. The hardness value of RTE shrimp coated with C reduced from 2801.21 to 507.95, while the sample of RTE shrimp coated with CL and CO were reduced to 625.67 and 530.02, respectively. The springiness value of RTE shrimp coated with C was reduced from 39.711 to 29.441, while the RTE shrimp coated with CL and CO were reduced from 44.94 to 32.89 and from 39.42 to 30.31, respectively. According to Gan et al. [20], the texture deterioration of seafood such as RTE shrimp was due to the presence of endogenous enzymes and collagenase lead to the softening and dehydration of muscle. Lipid oxidation also occurs in seafood and contributes to quality losses, which includes texture and color [21][22]. Ge et al. [23] also reported that endogenous enzyme activity was related to proteolysis and textural softening of grass carp muscle during chilled storage. This could be explained by the fact that the chitosan-based coating had effectively inhibited collagenase and endogenous enzyme activities, thus reducing protein degradation, and finally retarding textural deterioration.

Table 1: Physicochemical properties of ready-to-eat shrimp coated with chitosan (C), chitosan incorporated with essential lemon oil (CL) and chitosan incorporated with olive oil (CO) during storage at 6 ˚C for 14 days

Analysis	Day of Storage, day	Coating		
		C	CL	CO
pH	0	6.30±0.01	6.16±0.01	6.27±0.03
	2	6.36±0.01	6.23±0.02	6.33±0.10
	7	6.69±0.01	6.36±0.01	6.43±0.01
	10	6.72±0.03	6.43±0.01	6.53±0.05
	14	6.87±0.01	6.50±0.04	6.60±0.06
L* value	0	88.23±0.70	85.00±0.64	83.45±0.67
	2	86.53±0.57	87.52±0.52	76.26±0.28
	7	75.60±0.87	76.12±0.43	65.99±0.68
	10	63.89±0.90	68.43±0.54	64.66±0.89
	14	62.08±0.0.50	67.41±0.47	63.32±1.15
a* value	0	13.63±0.86	13.44±0.79	12.89±1.07
	2	11.59±0.57	12.59±1.02	11.18±0.37
	7	10.07±1.00	11.18±0.68	9.54±1.01
	10	9.27±0.59	10.74±0.97	9.27±0.69
	14	9.21±0.23	10.66±1.04	7.24±1.89

b* value	0	13.24±0.17	13.33±2.01	13.25±0.79
	2	12.64±1.17	13.12±1.99	11.09±1.13
	7	9.89±1.02	10.76±0.69	10.56±1.00
	10	8.67±1.06	10.01±3.52	10.43±0.86
	14	8.01±1.11	8.99±1.09	8.36±0.98
Hardness value	0	2801.211±4.56	2187.786±2.79	2244.173±1.03
	2	1397.621±3.97	2126.282±0.99	1769.761±2.58
	7	669.131±4.87	944.684±4.45	770.321±4.56
	10	518.333±2.99	781.329±4.53	587.891±5.06
	14	507.951±1.00	625.667±0.97	530.021±0.98
Springiness value	0	39.71±1.02	44.935±0.27	39.417±0.38
	2	39.463±0.28	40.251±1.03	38.641±0.87
	7	36.816±0.75	30.001±0.39	37.741±1.02
	10	33.154±4.04	37.331±0.87	35.004±2.02
	14	29.441±0.77	32.888±0.55	30.312±1.01

4. Conclusion

In summary, the chitosan coating incorporated with lemon essential oil provided better quality preservation the quality of RTE shrimp in terms of color (L*, a* and b* value) and texture (hardness and springiness), as compared to chitosan coating or chitosan incorporated with olive oil.

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