

EFFECTS OF PASTEURIZATION AT DIFFERENT TEMPERATURE AND TIME ON MARINATED SHRIMP IN GREEN CURRY

(Kesan Pempasteuran Pada Suhu dan Masa yang Berbeza Bagi Produk Peraman Udang Di Dalam Kari Hijau)

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Abstract

The effects of pasteurization on marinated shrimp in green curry paste at 5 conditions (T1) 65°C for 32.5 minutes, (T2) 67°C for 18.5 minutes, (T3) 68°C for 17 minutes, (T4) 69°C for 7 minutes, (T5) 70°C for 7 minutes in comparison with the control (non-pasteurized) sample was studied. TVC of pasteurized marinated shrimp (T1 to T5) was lower than 10 CFU/g and *Listeria* spp. was not detected in 25g sample, while the TVC for control was 3.67 log CFU/g and *Listeria* spp. was 1.18 log CFU/g. The pH value of pasteurized marinated shrimp (T1 to T5) was significantly lower than the non-pasteurized marinated shrimp. The shear force value for samples pasteurized at T3, T4 and T5 was not significantly different from control. Sensory evaluation result showed that the highest score for overall acceptability was 5.75 for the product pasteurized at 70°C for 7 minutes (T5). Treatment 5 (70°C for 7 minutes) was selected as optimum condition for pasteurized sample for shelf life study. From shelf life study, the pasteurized marinated shrimp in green curry paste was safe for consumption until the end of storage period for 15 days at 0-3°C. There was no significant difference between pasteurized products stored at 0-3°C with freshly prepared product up to 15 days for all attributes that were sensorial tested.

Keywords: *litopenaeus vannamei*, marinated shrimp, green curry, pasteurization, shrimp

Abstrak

Kesan pempasteuran pada udang diperap dalam pes kari hijau pada 5 keadaan iaitu (T1) 65°C selama 32.5 minit, (T2) 67°C selama 18.5 minit, (T3) 68°C selama 17 minit, (T4) 69°C selama 7 minit, (T5) 70°C selama 7 minit dengan membuat perbandingan antara sampel kawalan (tidak dipasteur) bagi sampel yang dikaji. Jumlah TVC bagi udang perap yang dipasteur (T1 hingga T5) adalah lebih rendah daripada 10 CFU / g dan *Listeria* spp. tidak dikesan dalam sampel 25g, manakala TVC untuk sampel kawalan adalah 3.67 log CFU / g dan *Listeria* spp. adalah 1.18 log CFU / g. Nilai pH udang perap yang dipasteur (T1 untuk T5) adalah jauh lebih rendah daripada udang perap yang tidak dipasteur. Nilai tekstur bagi sampel yang dipasteur pada suhu T3, T4 dan T5 tidak berbeza secara signifikan daripada produk kawalan. Hasil ujian penilaian deria menunjukkan bahawa skor tertinggi untuk penerimaan keseluruhan adalah 5.75 untuk produk yang dipasteur pada suhu 70°C selama 7 minit (T5). Ujian 5 (70°C selama 7 minit) telah dipilih sebagai keadaan optimum untuk sampel pempasteuran untuk kajian jangka hayat produk. Berdasarkan kajian jangka hayat penyimpanan, udang perap dalam pes kari hijau yang telah dipasteur adalah selamat untuk dimakan untuk tempoh jangkamasa selama 15 hari pada suhu 0-3°C penyimpanan. Tidak terdapat perbezaan yang signifikan di antara produk yang telah dipasteur dan disimpan pada suhu 0-3°C berbanding produk yang disediakan segar sehingga 15 hari penyimpanan untuk semua atribut penilaian deria.

Kata kunci: *litopenaeus Vannamei*, udang peraman, kari hijau, pempasteuran, udang

Introduction

White shrimps (*Litopenaeus vannamei*) are one of the dominant economically important products of Thailand. Lindner et al. [1] reported that the softening of freshwater prawn tissue was occurred on 7-9 days of storage at 0°C because of degradation of muscle components, due to the proteolytic activities. The changes in texture of thawed shrimp were negative economic factor. Shrimp muscle increases in firmness by heat processing and becomes too firm, lack of juiciness and unpalatable when heating temperature exceeds 70°C [2]. Current trends show increasing consumer demand for consumer ready products with smaller portion sizes and less fat, as well as being ready-to-eat. In modern lifestyle, there has been an increasing number in smaller families with less cooking activity. They also keep demanding for fresh foods with ease of preparation are also on the increase. Convenient chilled foods including ready-to-cook shrimp green curry paste is suitable for modern consumers for the above mentioned reasons. Green curry is the second most favourite dish among consumers in Thailand because of its taste, flavour and appearance [3]. Many fresh ingredients used in the formulation of green curry paste have been found to possess antimicrobial and antioxidant activity as well as medicinal values. Thai green curry demonstrated antibacterial activity against seafood spoilage organism and foodborne pathogens [4]. Marinades using these ingredients can help improving the shelf-life of the products. However, to completely ensure the safety of the ready-to-cook product that kept in chilled condition (0-3°C), pasteurization should be employed to minimize microbial load. This study aimed to develop pasteurized ready-to-cook marinated shrimps in green curry paste. As the ingredients of ready-to-cook shrimp in green curry paste was in the raw state, to reduce the microbial load and prolong the shelf life, pasteurization at 5 conditions (T1) 65°C for 32.5 minutes, (T2) 67°C for 18.5 minutes, (T3) 68°C for 17 minutes, (T4) 69°C for 7 minutes, (T5) 70°C for 7 minutes were studied with comparison to the control (non-pasteurized) sample. The condition that was suitable for the product to achieve a 6 log reduction of *L. monocytogenes* and maintain the quality of the white shrimp was determined.

Materials and Methods

Pasteurization

The treated shrimp was mixed with green curry paste with shrimp to green curry paste ratio 2:1 (w/w). About 80±2g of shrimps was packed along with 40±2g curry in a pouch to maintain a pack weight of about 120g. The green curry paste developed by Charoan Pokphand Food Public Company from Thailand was used in this study. The products in stand up pouch were pasteurized using hot water bath to achieve 6 log reductions of *L. monocytogenes* according to recommendations from FDA [5] for fish and seafood products and ECFF [6]. The pasteurization conditions employed were: (T1) 65°C for 9.3 minutes, (T2) 67°C for 5 minutes, (T3) 68°C for 3.7 minutes, (T4) 69°C for 2.7 minutes and (T5) 70°C for 2 minutes with comparison to the control (non-pasteurized) sample, the experiments was done in two replicates using Completely Randomized Design (CRD). Cooling process was done rapidly after the pasteurization process by immersing the pouch in an ice water bath (10±2°C) for 2 minutes at control room temperature (25±2°C). The cooled pack was dried, labeled and stored at 0-3°C for 15 days in a chiller [7]. The temperature profile analysis for pasteurization in package was done by inserting the thermocouple in the pouch and the accumulated lethality (F_0) was calculated. Five treatments of pasteurized sample and non-pasteurized sample were analyzed according to the procedure in 2.1.1, 2.1.2, 2.1.3 and 2.1.4. The analysis of physical, chemical and microbiology result was done using Completely Randomized Design (CRD). The analysis of sensory evaluation result was done using Randomized Complete Block Design (RCBD). One optimum pasteurization condition that yielded the product with the highest score for sensory evaluation and good characteristics was used in the shelf-life study.

pH Analysis

The pH value was recorded using a pH meter Consort C860 (Consort, Turnhout, Belgium). Each measurement was replicated three times with two replicates. Thirty grams of shrimp was homogenized with 150 ml distilled water at sample to water ratio 1:5 (w/v) and allowed to dissolve for 2 minutes before the analysis. The pH meter was calibrated with standard buffers of pH 4.0 and 7.0 before the measurement [8].

Colour Analysis

Colour of the raw and treated shrimps, the gravy (green curry) and the homogenized sample (marinated shrimp in green curry) were measured using a Chroma meter CR-400 (Minolta, Osaka, Japan). The color was expressed in CIE Lab system L^* , a^* , and b^* values, where L^* denotes lightness on a 0-100 scale from black to white, a^* (+) red

or (-) green and b^* (+) yellow or (-) blue [9]. This instrument was calibrated with white reference tiles ($Y=93.5$; $x = 0.3132$; $y = 0.3198$) before the analysis. The shrimp was placed on white tray above the light sources and will be measure directly. Glass cell containing the green curry and homogenized sample of shrimp with green curry was placed above the light sources and L^* , a^* , b^* values were then recorded. Five readings were done for each sample with two replicates [10].

Texture Analysis

Shear force determination was carried out at room temperature of $25 \pm 2^\circ\text{C}$. The maximum force required to cut the sample (Newton) was recorded. The shear force of samples was measured using a texture analyser (Stable Micro System; TA.XT2i, England) with a Warner-Bratzler blade. The operating parameters used are cross-head speed of the machine 10 mm/s. The maximum force to cut at the centre of the second abdominal segment is about 1 mm at 45° angle of the shrimp was recorded as the shear force [10]. The measurement was replicated ten times for each sample with two replicates.

Microbiological Analysis

The microbiology analysis of raw shrimp that had been done included total plate count [11]. *Staphylococcus aureus* tested using 3M™ Petrifilm™ Staph Express Count Plates (AOAC Official Method 2003.11)[12]) and *Escherichia coli* using 3M™ Petrifilm™ E.coli/Coliform Count Plates (AOAC Official Method 998.08 [12] for *E.coli* and AOAC Official Method 991.14 [12] for Coliform) with two replicates. Non-pasteurized sample and five pasteurized samples for the selection of pasteurization parameter were analyzed for the total plate count using Compact Dry Total Count, AOAC. No. 010404 (Mizuochi and Kodaka [13]) and *Listeria* spp. was analyzed using Compact Dry LS 'Nissui', ISO 11290 [14]. The analysis was replicated.

Results and Discussion

Optimum pasteurization parameter

For pasteurization in package, temperature profile analysis (Table 1) was done to get the actual time, F value and lethal rate for the marinated shrimp in green curry paste. The calculations for accumulated lethality using general method are shown in Appendix C. The average of the actual time was significantly different ($p \leq 0.05$) between treatment (T1 to T5) and there was no significant different between replicates ($p > 0.05$). The average of the actual time from two replicates was as follow: T1) 65°C for 32.0 minutes (T2) 67°C for 18.0 minutes, (T3) 68°C for 16.5 minutes, (T4) 69°C for 6.5 minutes and (T5) 70°C for 6.5 minutes (Table 1). The pasteurized marinated shrimp in green curry paste were reproduced at 5 conditions using the conditions in replicate two: (T1) 65°C for 32.5 minutes, (T2) 67°C for 18.5 minutes, (T3) 68°C for 17 minutes, (T4) 69°C for 7 minutes and (T5) 70°C for 7 minutes in comparison with the control (non-pasteurized) sample for two replicates using Completely randomized design (CRD) (Table 1). Initial product temperature was set at 25°C . The condition that yielded pasteurized product with the highest score for sensory evaluation and good characteristics from the other analysis was chosen for the shelf-life study.

The results on total viable count, *Listeria* spp., shear force, pH and colour of pasteurized marinated shrimp in green curry paste is shown in Table 2. The pH value of pasteurized marinated shrimp in green curry (T1 to T5) was significantly lower than the non-pasteurized marinated shrimp (control). Total viable count (TVC) of pasteurized marinated shrimp (T1 to T5) was < 10 CFU/g and *Listeria* spp. was not detected in 25g sample while the TVC for non-pasteurized marinated shrimp was $3.67 \log$ CFU/g and *Listeria* spp. $1.18 \log$ CFU/g. The TVC in non-pasteurized sample was reduced $0.6 \log$ CFU/g and the count of *Listeria* spp. was reduced about $1.58 \log$ CFU/g compared with raw shrimp. Ko, Mendonca and Ahn [15] reported that an addition of 0.5% citric acid in ham in vacuum-packaged resulted in synergistic effect against *L. monocytogenes* and *E.coli* 0157:H7. After 8 days storage at 4°C , the count of *L. monocytogenes* and *E.coli* 0157:H7 was $< 1 \log$ CFU/g. Gonzalez-Fandos, Herrera, and Maya [16] reported that chicken leg washed with 0.156 M (3%) citric acid for 5 minutes showed a significant ($p < 0.05$) inhibitory effect on *L. monocytogenes* compared with the control leg, being about $1.55 \log$ CFU/g unit lower than control legs after 1 day of storage. The shear force value for sample (T3, T4 and T5) was not significantly different from control ($p > 0.05$) (Table 2). This finding was good for a better texture quality of shrimp products after the pasteurization process. Benjakul et al. [17] reported that the shear force of black tiger shrimp and white shrimp meat increased markedly when the samples was heated for longer than 0.5 minutes ($p < 0.05$). The L^* , a^* and b^* value of

homogenized samples (non-pasteurized and pasteurized marinated shrimp in green curry paste) is shown in table 4.8. L* denote lightness on 0-100 scale from black to white, a* denote (+) red and (-) green; b* denote (+) yellow and (-) blue [9]. The L* value for pasteurized sample (treatment T1 to T3) was higher than non-pasteurized sample with a significant difference. The a* value for pasteurized sample for treatment T1 was increased, which means that it was more reddish. The b* value for T1 to T5 was not significant different from non-pasteurized sample. Benjakul et al. [17] reported that the L* a* b* value of white shrimp was increased when heating time is more than 0.5 to 1 minutes (p<0.05).

Table 1. Thermal processing time needed to obtain 6 log reduction of *Listeria monocytogenes* (Z = 7.5) based on recommended condition by FDA (2011) and accumulated lethality from temperature profile analysis

Condition	Internal product temperature (°C)	Time required for 6D Process (minute)	Actual Time (minute)		Average Actual Time (minute)	Accumulated lethality at 70°C (minute)	
			Replicate 1	Replicate 2		Replicate 1	Replicate 2
T1	65	9.3	31.5	32.5	32.0 ^a ±0.7	2.064	2.016
T2	67	5.0	17.5	18.5	18.0 ^b ±0.7	2.109	2.013
T3	68	3.7	16.0	17.0	16.5 ^c ±0.7	2.041	2.106
T4	69	2.7	6.0	7.0	6.5 ^d ±0.7	2.003	2.020
T5	70	2.0	6.0	7.0	6.5 ^d ±0.7	2.067	2.174

Initial product temperature 25±2°C. Means with different superscripted letters in the same column are significantly different (p<0.05).

Table 2. Total viable count, *Listeria* spp., shear force, pH and colour of non-pasteurized and pasteurized marinated shrimp in green curry paste

Sample	TVC (log cfu/g)	<i>Listeria</i> spp. (log cfu/g)	Shear Force (Newton)	pH	L*	a*	b*
Control	3.67±0.10	1.18±0.0	17.94 ^a ±0.45	7.68 ^a ±0.02	44.80 ^b ±2.23	1.61 ^b ±1.05	15.10 ^a ±2.31
T1	<10 cfu/g	ND	15.27 ^c ±0.57	7.42 ^e ±0.56	48.73 ^a ±0.44	2.48 ^a ±0.47	16.86 ^a ±2.15
T2	<10 cfu/g	ND	16.74 ^b ±0.08	7.46 ^d ±0.42	48.12 ^a ±1.39	2.08 ^{ab} ±0.88	17.14 ^a ±2.96
T3	<10 cfu/g	ND	17.77 ^a ±0.31	7.49 ^c ±0.42	48.98 ^a ±0.44	2.12 ^{ab} ±0.90	16.78 ^a ±3.17
T4	<10 cfu/g	ND	18.14 ^a ±0.23	7.52 ^b ±0.42	47.40 ^{ab} ±2.19	1.77 ^b ±0.81	16.39 ^a ±4.57
T5	<10 cfu/g	ND	18.33 ^a ±0.44	7.54 ^b ±0.03	47.83 ^{ab} ±1.13	1.70 ^b ±0.48	15.75 ^a ±3.67
Raw shrimp	4.27±0.01	NT	NT	6.44±0.04	46.93±2.31	-0.68±0.29	-4.90±1.08
Green curry	NT	NT	NT	5.10±0.03	34.47±0.17	-0.40±0.04	14.51±0.10

Mean value ± standard deviation. Initial product temperature was set at 25°C. ND= Not detected in 25g sample. NT= Not tested. Control= Non-pasteurized marinated shrimp in green curry. T1-T5= Pasteurized marinated shrimp in green curry paste; T1= 65°C for 32.5 minutes, T2 = 67°C for 18.5 minutes, T3 = 68°C for 17 minutes, T4 = 69°C for 7 minutes and T5 =70°C for 7 minutes. Homogenized samples were used for microbiology, pH and colour analysis. Means with different superscripted letters in the same column are significantly different (p<0.05).

Sensory evaluation result in Table 3 showed that the highest score for overall acceptability was 5.75 (T5). The sensory evaluation was done by 10 trained panelists using nine category scales 0-8 (0: None, 2: Slightly, 4: Moderate, 6: Very, 8: Extremely like). The firmness score was not significantly different from control and the highest score was 5.15 (T5), this was related to the lowest score for the tenderness of the texture (3.68). The decrease of shrimp tenderness was attributed to decrease in protein solubility during marinating and pasteurization. The juiciness score was not significantly different between samples and the highest score was 5.40 (T5) and the toughness score was also increased to 4.38. Overall, pasteurization condition in treatment T5 (70°C for 7 minutes) was selected as the optimum pasteurization parameter for marinated shrimp in green curry paste.

Table 3. Sensory evaluation of non-pasteurized and pasteurized marinated shrimp in green curry paste using Quantitative descriptive analysis

Sample	Colour of green curry ns	Colour of shrimp ns	Odour ns	Sweetness ns	Saltiness	Off Flavour
Control	4.38±0.92	4.89±1.13	4.20±1.11	3.24±1.09	4.17 ^a ±0.93	0.0
T1	4.77±1.10	5.09±1.06	4.08±0.89	3.41±0.83	3.89 ^{ab} ±0.84	0.0
T2	4.60±1.03	5.09±1.10	4.48±0.74	3.20±0.80	3.96 ^{ab} ±0.75	0.0
T3	4.43±0.67	4.99±1.18	4.31±0.85	3.35±1.04	3.76 ^b ±1.02	0.0
T4	4.31±0.71	5.00±0.72	4.13±1.13	3.24±1.02	3.95 ^{ab} ±0.72	0.0
T5	4.65±0.78	5.27±1.00	4.49±1.12	3.31±0.83	3.75 ^b ±0.74	0.0
	Texture: Juiciness	Texture: Toughness ns	Texture: Tenderness	Texture: Firmness	Overall acceptability	
Control	5.03 ^{ab} ±0.73	4.11±1.10	3.86 ^{ab} ±1.23	4.85 ^{ab} ±0.70	5.09 ^b ±1.23	
T1	4.94 ^b ±1.00	4.21±1.18	4.22 ^a ±1.21	4.57 ^b ±0.66	4.71 ^b ±1.11	
T2	4.87 ^b ±0.72	3.97±0.93	4.07 ^{ab} ±0.97	4.53 ^b ±0.90	4.81 ^b ±0.97	
T3	4.95 ^b ±0.71	3.92±0.91	4.09 ^{ab} ±1.02	4.66 ^{ab} ±0.67	4.84 ^b ±1.10	
T4	5.10 ^{ab} ±0.83	4.23±0.75	4.07 ^{ab} ±0.87	4.80 ^{ab} ±0.64	4.94 ^b ±1.36	
T5	5.40 ^a ±1.24	4.37±0.77	3.68 ^b ±0.91	5.15 ^a ±1.17	5.75 ^a ±1.14	

Mean ± standard deviations were evaluated by 10 trained panelists using nine category scales 0-8 (0: None, 2: Slightly, 4: Moderate, 6: Very, 8: Extremely like). Control = Non-pasteurized, T1= 65°C for 32.5 minutes, T2 = 67°C for 18.5 minutes, T3 = 68°C for 17 minutes, T4 = 69°C for 7 minutes and T5 =70°C for 7 minutes. ns= not significantly different (p>0.05). Means with different superscripted letters in the same column are significantly different (p≤0.05)

Conclusion

For pasteurization parameter, treatment 5 (T5; 70°C for 7 minutes) with accumulated lethality of 2.17 minutes at 70°C was selected as the suitable pasteurization condition for marinated shrimp in green curry paste. The product pasteurized using condition T5 got the highest score for overall acceptability (5.75). After pasteurization, the safety level of marinated shrimp in green curry paste was increased up to 15 days.

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