Effects of Soaking in Water at Different Temperatures and Time on Color of Cooked Pacific White Shrimp (*Litopenaeus vannamei*) Raised under Low and Normal Salinity Waters

Dechanarth Thongphitak[1], Chalor Limsuwan[1], Niti Chuchird[1], Nongnuch Raksakulthai[2] and Nantipa Pansawat[2]

ABSTRACT

The effects of water temperature and soaking time on color of cooked Pacific white shrimp (*Litopenaeus vannamei*) raised under low and normal salinity water were studied. It was found that shrimp raised in both low and normal salinity levels soaked at 20°C for 15 minutes had the lowest lightness (L*) which was significantly different from control group (without soaking). However, redness (a*) and yellowness (b*) were not significantly different. Apparently, shrimp soaked at 20°C for 45 minutes had the highest a*, while those soaked at 10°C for 45 minutes had the highest b* and shear force (N). The sensory evaluation scores on color intensity of the shell, color, transparency and firmness of the meat determined by eight trained panelists were not significantly different (P>0.05), but photographically, the difference in overall color intensity of control and shrimp soaked at 20°C for 45 minutes could be detected.

Keywords: Pacific white shrimp, *Litopenaeus vannamei*, lightness, redness, yellowness

INTRODUCTION

The shrimp farming industry has grown very rapidly in the last two decades, with a wide variety of different shrimp and prawn species being cultured in many parts of the world. The two predominant areas for large-scale culture today are Asia and South America. Pacific white shrimp (*Litopenaeus vannamei*) is widespread along the eastern coast of the Pacific Ocean from Mexico to northern Peru (Holthuis, 1980; Perez and Kensley, 1997). In Asia, the black tiger shrimp (*Penaeus monodon*) is the most

[1]Department of Fishery Biology, Faculty of Fisheries, Kasetsart University, Bangkok 10900. Thailand
[2]Department of Fishery Products. Faculty of Fisheries, Kasetsart University, Bangkok 10900. Thailand

widely cultured type, particularly in Thailand, Indonesia, India, Vietnam, Sri Lanka, the Philippines and Malaysia. These countries together contribute about 60% of the world's total cultured shrimp production (Dey, 1995).

Currently, shrimp farming in Asia is undergoing a dramatic transformation. The Pacific white shrimp is rapidly replacing the black tiger shrimp as the main farmed species. This change began in Taipei China in the late 1990s with the importation of specific pathogen-free (SPF) broodstock of *L. vannamei* from Hawaii. The People's Republic of China then began to import this broodstock, followed by Thailand, Indonesia and Vietnam, and now the Pacific white shrimp is being cultured very extensively. The main reason for this change is that *L. vannamei* has a faster growth rate, higher yield and lower production costs than *P. monodon*. The biological basis of this advantage is related to the SPF and domestication status of imported *L. vannamei*. By contrast, *P. monodon* postlarvae are produced from wild-caught brooodstock which are non-domesticated and frequently contaminated with pathogens, including viruses.

Thailand has been the world's leading shrimp exporter for over 15 years. In the last two years, more than 80% of the products were from white shrimp. At present, the main purchasing countries have a greater opportunity to choose good quality white shrimp from several countries.

One disadvantage of white shrimp is paler color after cooking compared with black tiger shrimp due to the thiner shell and less pigmentation. This is because white shrimp farming uses an intensive culture system with a high stocking density resulting in a heavy amount of suspended solids in the water especially in the earthen ponds. The large amount of suspended solids prevents the formation of a good phytoplankton bloom which is an important source of pigments or carotenoids for shrimp (Limsuwan and Chanratchakool, 2004). Supplemental dietary canthaxanthin and astaxanthin fed to black tiger shrimp for four weeks caused a darker color and reduced blue appearance in the shrimp (Boonyaratpalin *et al.*, 1994). However, adding such carotenoids highly increased the production costs, which could further impact profits, especially as the price for white shrimp is lower than that of black tiger shrimp. The shrimp farmers' method of choice for producing good coloration in shrimp should be both easy to apply and inexpensive.

It is well documented that during stress period, shrimp will produce carotenoid pigments therefore; the objective of this research was to determine the effects of soaking live white shrimp after harvesting in water at different temperatures and time on the color of cooked head-on and shell-on shrimp product.

MATERIALS AND METHODS

Preliminary tests were done in the laboratory to determine the appropriate cooking time for white shrimp after soaking them in water at different temperatures and time. The shrimp was boiled in water until the core temperature reached 70°C according to Thai Agricultural Commodity and Food Standard for cooked shrimp products (TACFS. 7017-2006, 2006). An additional 50 seconds was added to the boiling time of each group to get the appropriate boiling time use in the study.

In experiment 1, white shrimps from three earthen ponds culturing under low salinity conditions ranging from 3-5 parts per thousand (ppt.) were studied. Shrimp were sampled by using a cast net and 50 shrimp were put into buckets (0.1 cubic m) containing water at 10°C and 20°C, with three buckets for each temperature. Three buckets for each temperature. Three replicates were done for each pond. For the control group, the shrimp were not first soaked in the water but were cooked directly after sampling from the ponds. Shrimp samples from each experimental group were cooked after soaking at the different water temperatures for 15, 30 and 45 minutes. Shrimp samples were then packed in ice and transported to Department of Fishery Products, Faculty of Fisheries for further studies on the color intensity.

Color intensity of the shell was determined by CIE (International Commission on Illumination) L^*, a^* and b^* using a Minolta Spectrophotometer CM-3500 d (Japan). The hardness of the meat was determined by peeling off the shell and then using shear cutting force by the texture Analyzer Stable Micro System (UK) with a Warner-Blatzler blade at a speed of 2 mm per second, cut transversely at the third abdominal segment.

Sensory evaluation was done by eight trained panelists from the Department of Fishery Products. The parameters evaluated were: color intensity of the shell, color of the meat, transparency of meat and firmness of meat using finger pressure. Judges were asked to compare the intensity of each attribute on an unconstructed line of 15 cm. with control set at 7.5 cm.

In the second experiment, white shrimp

cultured in normal salinity conditions ranging from 30-35 ppt were studied. All the sampling procedures and evaluation were the same as in the first experiment.

Data from all experimental groups were analyzed statistically. Duncan's Multiple-Range Test was used to examine for significant differences among treatments (Steel and Torrie, 1980).

RESULTS AND DISCUSSION

The preliminary study for the suitable cooking time for white shrimp revealed that the core temperature of cooked shrimp from the controls (not pre-soaked in water) reached 70°C in 160 seconds. In the 10°C and 20°C groups, the temperature reached 70°C in 180 and 170 seconds, respectively.

The color intensity of shrimp from all experimental groups is shown in Table 1 and Figure 1. Shrimp soaked at 20°C for 15 minutes had the lowest lightness (L*) which was significantly different compared with the other groups ($P<0.05$). Shrimp soaked at 20°C for 30 and 45 minutes also had a lower lightness (L*) compared with the control group ($P<0.05$). However, redness (a*) and yellowness (b*) were not significantly different among the experimental groups ($P>0.05$). Apparently, shrimp soaked at 20°C for 45 minutes had the highest a*. Shrimp from 20°C group did not die during the experiment but developed more intense red body color due to stress. The results from this study were similar to those reported by Chuchird (1995) and Latsha (1990) who stated that stressed shrimp released more carotenoids in the beta-carotene form which led to the appearance of darker body coloration. Shrimp soaked at 10°C had the highest shear force (N) (Table 1). Shrimp from ponds 1 and 3 soaked in 10°C water for 45 minutes had the highest shear force, while in pond 2 the highest shear force was found in the group soaked at 10°C for 15 minutes. These results indicated that soaking shrimp at a lower temperature will increase the shear force value. Benjakul (2005) reported that storage fishery products at low temperatures could inhibit enzymatic and microbial activity which resulted in a better quality of meat.

From Table 2, sensory evaluation scores by eight trained panelists on color intensity of the shell, color, transparency and firmness of the meat were not significantly different ($P>0.05$), but a photographically difference in overall color intensity of the control shrimp and those soaked at 20°C for 45 minutes could be detected (Figure 2). Similar results from the shrimp samples reared in normal salinity water were observed (Figure 3 and 4). The redness (a*) of the shrimp in low and normal salinity water was not significantly different (P>0.05). The redness of the shell was related to the abundance of phytoplankton more than the salinity. Prawitwilaikul (2004) reported that white shrimp reared in the polyethylene-lined pond with an abundance of phytoplankton showed more reddish color than those from the earthen ponds that had lower numbers of phytoplankton. In our study, water in the normal salinity pond was cloudy due to heavy amounts of suspended solids following heavy rains prior to our study. In contrast, the low salinity water had a greater abundance of phytoplankton during the course of study.

Table 1 L*, a*, b* and shear force of shrimp raised under low salinity and soaked in water at different temperatures and lengths of time before cooking

	Control	10°C 15 minutes	10°C 30 minutes	10°C 45 minutes	20°C 15 minutes	20°C 30 minutes	20°C 45 minutes
Pond 1							
L*	59.23 ± 0.30^{a}	58.29 ± 0.51^{ab}	57.73 ± 0.51^{ab}	58.02 ± 0.8^{ab}	54.79 ± 1.89^{c}	56.60 ± 0.69^{b}	57.08 ± 0.49^{b}
a*	20.95 ± 0.78	21.35 ± 0.26	22.16 ± 1.40	22.59 ± 0.19	21.93 ± 1.14	21.45 ± 0.96	22.60 ± 1.22
b*	21.70 ± 0.78	22.27 ± 1.39	$23.01\pm.033$	23.15 ± 0.45	22.89 ± 1.24	22.09 ± 0.53	22.44 ± 0.50
N	16.42 ± 0.47^{b}	18.27 ± 0.96^{ab}	19.03 ± 0.48^{a}	19.56 ± 0.54^{a}	18.64 ± 0.47^{a}	18.11 ± 0.9^{ab}	18.37 ± 1.09^{a}
Pond 2							
L*	60.06 ± 0.85^{a}	58.26 ± 1.56^{a}	57.75 ± 0.68^{ab}	57.75 ± 2.57^{ab}	53.56 ± 0.75^{c}	55.41 ± 0.74^{bc}	55.50 ± 0.84^{bc}
a*	21.05 ± 2.39	21.18 ± 1.12	22.28 ± 0.84	22.22 ± 0.44	21.94 ± 0.87	21.41 ± 1.89	22.97 ± 0.55
b*	21.39 ± 1.73	22.68 ± 1.92	24.29 ± 0.72	23.29 ± 1.65	22.45 ± 0.81	21.79 ± 1.49	22.86 ± 0.95
N	17.39 ± 0.57^{c}	20.84 ± 1.28^{a}	20.47 ± 1.43^{ab}	20.42 ± 0.82^{ab}	18.47 ± 0.33^{c}	18.87 ± 0.70^{bc}	18.86 ± 0.71^{bc}
Pond 3							
L*	59.46 ± 0.35^{a}	54.47 ± 3.43^{b}	53.99 ± 3.36^{b}	52.47 ± 2.54^{b}	51.25 ± 3.28^{b}	51.43 ± 2.58^{b}	50.85 ± 3.13^{b}
a*	21.61 ± 0.80	23.05 ± 0.63	22.78 ± 2.48	22.43 ± 0.66	23.48 ± 1.49	23.76 ± 1.21	23.93 ± 0.68
b*	20.55 ± 1.74	23.17 ± 1.84	22.39 ± 1.07	23.22 ± 0.81	21.92 ± 1.13	22.06 ± 0.54	22.38 ± 0.46
N	18.17 ± 0.72^{c}	21.11 ± 0.52^{a}	19.82 ± 0.84^{b}	21.19 ± 0.72^{a}	19.45 ± 0.44^{b}	19.34 ± 0.85^{bc}	19.28 ± 0.36^{bc}

N.B. Values in the same row followed by different letters are significantly different ($P<0.05$)

Table 2 Sensory evaluation on shell color intensity, color, transparency and firmness of meat of shrimp raised under low salinity and soaked in water at different temperatures and lengths of time before cooking

Pond	Soaking temp. and time	Sensory evaluation score (millimeter)			
		Shell color intensity	Meat color	Meat Transparency	Meat Firmness by finger pressure
1	Control	75.0 ± 0.0^{a}	75.0 ± 0.0^{a}	75.0 ± 0.0^{a}	75.0 ± 0.0^{a}
	10^{o}C 15 minutes	78.0 ± 27.7^{a}	74.2 ± 24.4^{a}	74.0 ± 5.2^{a}	74.0 ± 11.0^{a}
	10^{o}C 30 minutes	77.0 ± 10.2^{a}	73.1 ± 9.9^{a}	74.0 ± 5.1^{a}	78.2 ± 7.3^{a}
	10^{o}C 45 minutes	79.2 ± 21.2^{a}	74.0 ± 12.6^{a}	77.6 ± 3.5^{a}	77.1 ± 4.9^{a}
	20^{o}C 15 minutes	76.9 ± 7.2^{a}	71.3 ± 12.6^{a}	76.6 ± 4.7^{a}	76.8 ± 3.8^{a}
	20^{o}C 30 minutes	78.2 ± 17.5^{a}	74.1 ± 6.8^{a}	75.8 ± 7.0^{a}	74.0 ± 5.2^{a}
	20^{o}C 45 minutes	81.5 ± 17.2^{a}	74.3 ± 11.0^{a}	76.8 ± 5.4^{a}	75.1 ± 2.1^{a}
2	Control	75.0 ± 0.0^{a}	75.0 ± 0.0^{a}	75.0 ± 0.0^{a}	75.0 ± 0.0^{a}
	10^{o}C 15 minutes	76.6 ± 5.9^{a}	71.9 ± 9.1^{a}	75.1 ± 3.4^{a}	76.7 ± 3.8^{a}
	10^{o}C 30 minutes	76.4 ± 9.6^{a}	71.6 ± 11.3^{a}	76.4 ± 2.3^{a}	76.9 ± 4.8^{a}
	10^{o}C 45 minutes	73.9 ± 10.3^{a}	73.5 ± 5.6^{a}	77.2 ± 3.8^{a}	75.9 ± 3.8^{a}
	20^{o}C 15 minutes	71.3 ± 15.4^{a}	67.4 ± 8.9^{a}	72.7 ± 3.0^{a}	76.7 ± 4.4^{a}
	20^{o}C 30 minutes	74.1 ± 8.4^{a}	71.9 ± 8.8^{a}	76.0 ± 3.3^{a}	77.5 ± 4.4^{a}
	20^{o}C 45 minutes	77.9 ± 10.6^{a}	70.3 ± 10.8^{a}	76.4 ± 6.0^{a}	76.3 ± 8.4^{a}
3	Control	75.0 ± 0.0^{a}	75.0 ± 0.0^{a}	75.0 ± 0.0^{a}	75.0 ± 0.0^{a}
	10^{o}C 15 minutes	73.4 ± 7.7^{a}	73.8 ± 4.5^{a}	76.6 ± 6.6^{a}	74.6 ± 5.9^{a}
	10^{o}C 30 minutes	76.9 ± 8.3^{a}	73.5 ± 4.8^{a}	73.6 ± 6.6^{a}	71.7 ± 7.6^{a}
	10^{o}C 45 minutes	79.6 ± 9.4^{a}	73.5 ± 4.8^{a}	75.4 ± 5.1^{a}	74.5 ± 4.7^{a}
	20^{o}C 15 minutes	77.7 ± 13.6^{a}	73.8 ± 3.8^{a}	77.1 ± 8.4^{a}	73.0 ± 3.5^{a}
	20^{o}C 30 minutes	73.4 ± 9.1^{a}	73.5 ± 4.7^{a}	76.8 ± 4.5^{a}	72.7 ± 7.9^{a}
	20^{o}C 45 minutes	84.4 ± 4.0^{a}	74.4 ± 1.9^{a}	76.6 ± 5.2^{a}	73.3 ± 5.9^{a}

N.B. Values in the same row followed by different letters are significantly different ($P<0.05$)

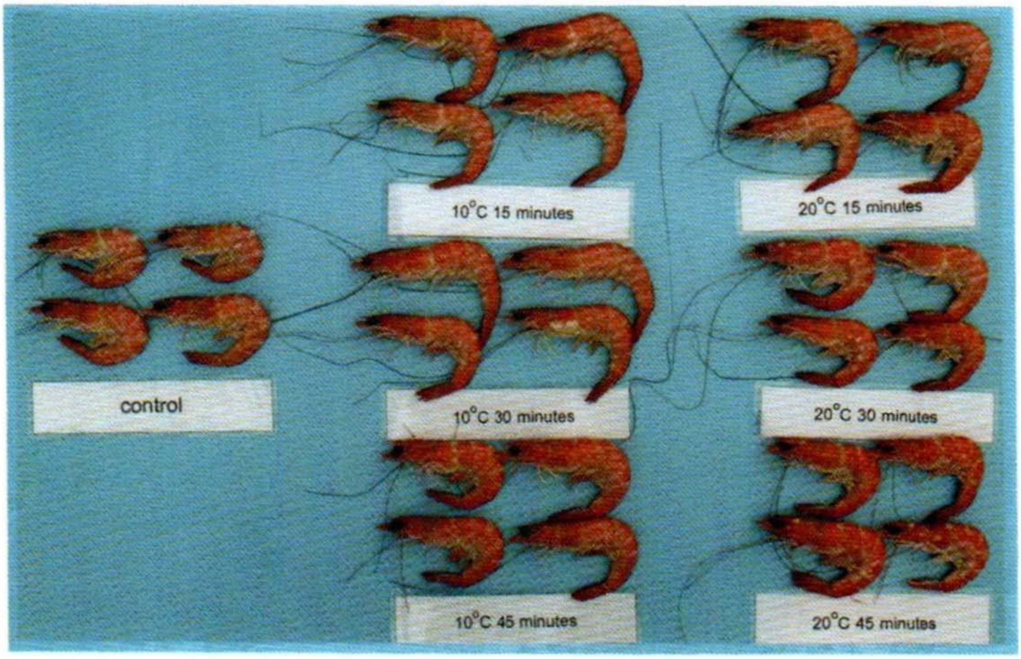

Figure 1 Color intensity of cooked white shrimp (raised in low salinity water) soaking in water at different temperatures and lengths of time.

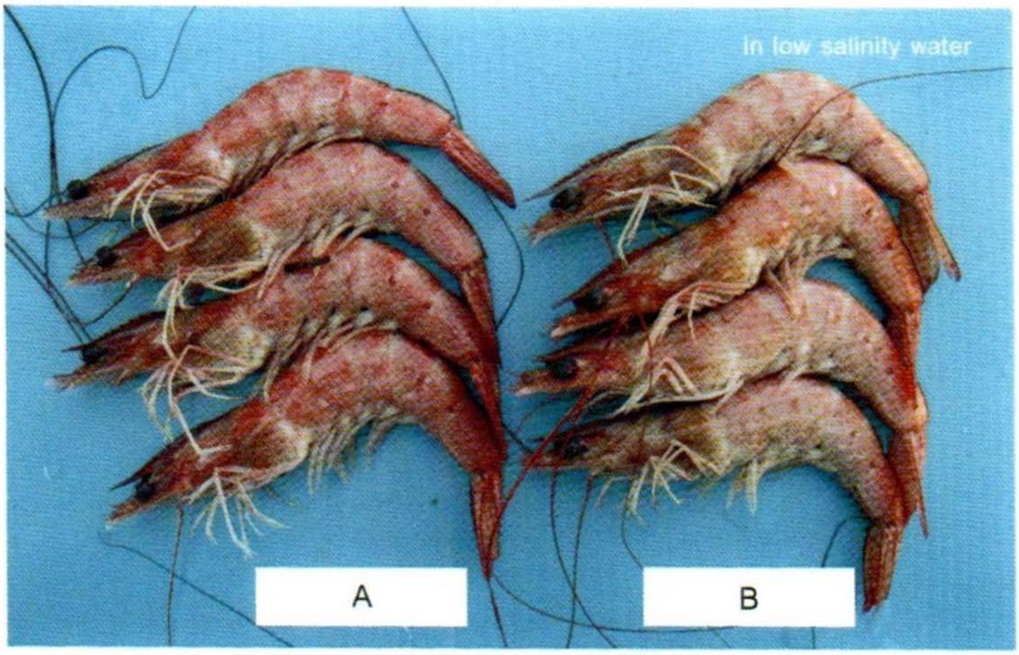

Figure 2 A = cooked white shrimp soaking in 20°C water for 45 minutes.
B = control cooked white shrimp.

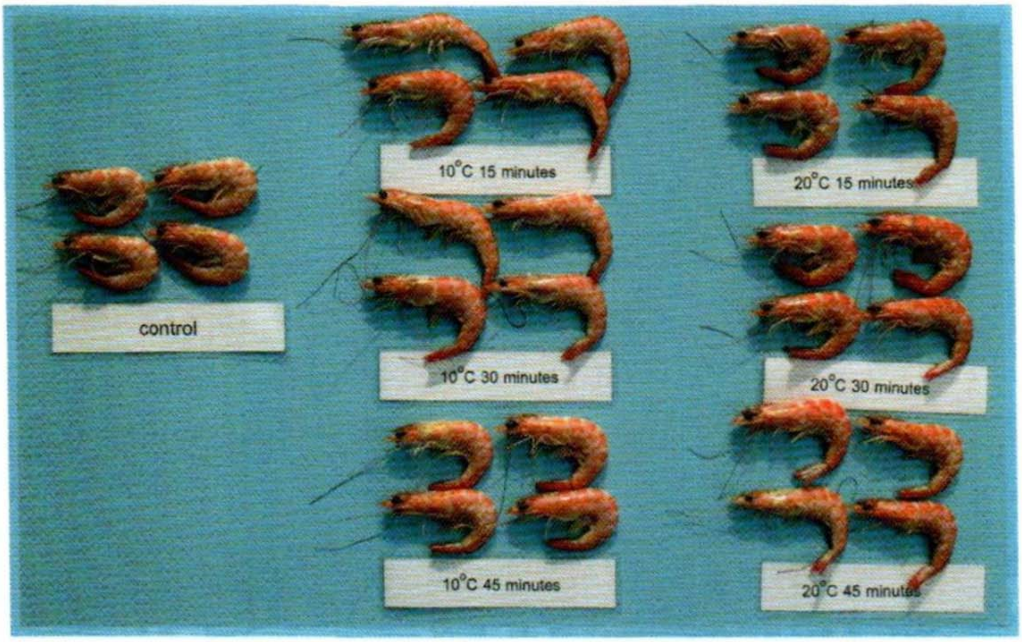

Figure 3 Color intensity of cooked white shrimp (normal salinity water) soaking in water at different temperatures and length of time.

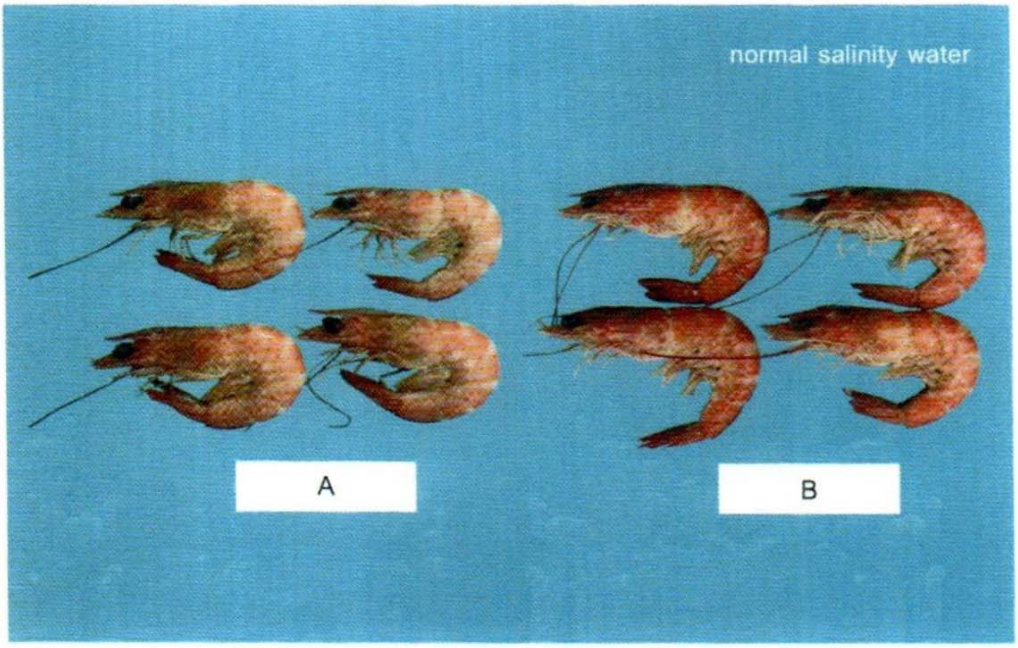

Figure 4 A = control cooked white shrimp.
B = cooked white shrimp soaking in 20°C water for 45 minutes.

CONCLUSION

Holding white shrimp in water at a temperature of 20°C for 15 minutes before cooking resulted in the lowest lightness. Although, the sensory evaluation score was not significantly different among different water temperatures and soaking times, but the difference in color intensity of control shrimp and shrimp soaked at 20°C for 45 minutes could be detected photographically. It is recommended that soaking shrimp for 45 minutes at 20°C is sufficient to retain its color intensity.

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