

EFFECT OF BACKGROUND COLOR AND NITRITE STRESS ON COOKED SHRIMP COLOR OF PACIFIC WHITE SHRIMP (*Litopenaeus vannamei*)

POOMKAEW KRITCH¹, ORAPINT JINTASATAPORN¹, SRINOY CHUMKAM²

¹Department of Aquaculture, Faculty of Fisheries, Kasetsart University,
Bangkok 10900, Thailand

²Faculty of Agricultural Technology, Valaya Alongkorn Rajabhat University,
Pathum Thani, Thailand

*Corresponding author :ffisora@ku.ac.th

Abstract:

The effect of background color and nitrite stress on cooked shrimp color of pacific white shrimp (*litopenaeus vannamei*) was conducted. Two factors of A: back ground color, black and white and B: no nitrite stress and with nitrite stress condition at 10 ppm were assigned in Factorial 2X3 in complete randomized designed (Factorial 2X3 in CRD) then 6 treatments and 3 replicates were studied. Shrimp with average weight of 7.43-8.21 gr/ind were exposure in treatment condition of no nitrite stress for 1 hr and with nitrite stress at 10 ppm for 1 hr and 24 hr then sampling for boiled and conducted color measurement by colorimeter and salmofan to compare the red intensity of cooked shrimp color. The results showed that the black background condition could promote the cooked shrimp color both in normal condition and under nitrite stress condition better than white background condition. The nitrite stress condition at 10 ppm could enhance the cooked shrimp color in short term periods of 1 hr. better than normal condition. For long term exposure to nitrite stress condition at 10 ppm for 24 hr., the stress condition reduced the redness of cooked shrimp color and reduced the carotenoid accumulation in shrimp.

Keywords: Cooked shrimp color; Background color: Nitrite stress

Introduction

White shrimp (*Litopenaeus vannamei*) are economically important aquatic animals and are widely cultivated in Latin America. North America and some countries in Asia. For Thailand, the introduction of white shrimp to culture since 1998 brought continuous income into the country for a high value. The trend of the white shrimp culture industry grows dramatically. However, shrimp feed is one of the factors that are variable for shrimp production and environment and considered as the main cost of culturing white shrimp (Valencia Castañeda, *et al.*, 2018).

The color of the shrimp after boiled is considered one of the main qualities that consumers and business people pay more attention to the price of white shrimp. The consumers in China and the European zone gives the high price of shrimp according to dark red after boiled compare to shrimp with light color. Hence, the red intensity of cooked shrimp color considers as an opportunity to increase revenue and increase business competition (Parisenti *et al.*, 2011)

During shrimp culture many factors effect on shrimp color especially water quality and disease infection. Ammonia and nitrite are widely present as a common toxic substance in aquatic systems. Nitrite is not only a toxic intermediate produced during ammonia nitrification

but also a product of denitrification of nitrate by bacteria during nitrogen cycle (Tomasso, 2012). Nitrite concentrations in coastal seawater are approximately 10–15 nM (0.14–0.21 NO₂-N µg/L) (Kieber & Seaton, 1995). However, in shrimp culture especially in closed system and biofloc system, nitrite concentration increases in middle and late-stage cultures. The nitrite concentration can reach 1.43 mM (20 NO₂-N mg/L) and seriously induces shrimp stress and effects the health of farmed animals (Tacon *et al.*, 2002).

Focusing on the behavior of shrimp, it is known that shrimp has ability to change their appearance to blend in with background color by moving the pigments in chromatophores in epidermal layers beneath the exoskeleton (Robison & Charlton, 1973). The movements of pigments in live shrimp have a direct effect on the color of cooked shrimp. This study intends to investigate the effect of background color and nitrite on the visual appearance of cooked shrimp color.

Materials and methods

Experimental animals

Five hundred white shrimp (*Litopenaeus vannamei*) with average weight of 7.43-8.21 gr/ind obtained from private farm at Nakorn Pathom, Thailand. Shrimp were culture in earth pond and fed diet without carotenoid supplementation for 2 months before move to acclimated in net cage of 3X4X1.5 m for 7 days before start the trial. Commercial feed (Grobest103S), protein 38% lipid 7% fiber <3% moisture <12% was applied to shrimp 2 times a day during acclimated periods.

Nitrite stress condition

The nitrite stress condition was set up by adding sodium nitrite 4.92 g in 100L water.

Experimental designed

The research was designed in the Factorial 2X3 in Complete Randomized Design (Factorial 2X3 in CRD). Two factors that influence on cooked shrimp color was assigned. Factor A was tank background color of black and white. Factor B was nitrite stress condition of no nitrite stress condition and nitrite stress condition at 10 ppm. Hence, the trial was 6 treatments and 3 replicates.

- T1: No Nitrite stress for 1hr in black background
- T2: Nitrite stress for 1 hr. in black background
- T3: Nitrite stress for 24 hr. in black background
- T4: No Nitrite stress for 1 hr. in white background
- T5: Nitrite stress for 1 hr. in white background
- T6: Nitrite stress for 24 hr. in white background

Experimental conditions

Shrimp with average weight of 7.43-8.21 gr/ind were randomly distributed into black and white tanks of each of 100 litter capacity that contain 12 ppt saline water. Shrimp were stocked at 25 ind/tank for 24 hr. During this time, shrimp was starvation, no feed was applied to shrimp. For

24 hr of nitrite stress condition, shrimp were sampling for boiled to determine the effect of background and nitrite stress condition on cooked shrimp color.

Data Collection: Cooked Shrimp Color Measurement

At the end of nitrite stress condition for 1 and 24 hr, ten shrimp from each treatment and replicate were sampling at each period for cooked and study on the color measurement. Cold shocked by ice was done immediately then boiled in 8% saltwater for 2 minute. The Salmon fan were used to measure shrimp color and graded score by colorimeter NH-1, measured on the first abdomen of shrimp compare to the fan. The C.I.E. LAB system (L*, a*, b*) refer to Brightness : L*, Red coloration :a*, Yellow coloration:b*. The total carotenoids (TC) was determined by weight sample then add extract solution of HEAT (Hexane:Acetone:Ethanol:Toluene 10:7:6:7) after that sonicate in cool and dark condition. Supernatant was recorded OD at 470 nm. The amount of total carotenoids was calculated.

Statistical data analysis

All the data from the experiment were subjected to analysis in Factorial 2x2 in CRD by statistical software. Duncan's Multiple Range Test was applied to compare the difference between experimental groups (Steel & Torrie, 1980).

Results and Discussion

The effect of background color and nitrite stress on cooked shrimp color of Pacific white shrimp (*litopenaeus vannamei*) was presented in Table 1.

Table 1: Color measurements of cooked shrimp (*Litopenaeus vannamei*) after stocked in black and white background under nitrite stress condition at different periods

Treatment	Background	Nitrite stress	L*	a*	b*	carotenoid
T1	Black	No Nitrite 1 hr	53.79±4.13 ^b	17.24±2.16 ^b	18.69±1.63 ^{bc}	1.501±0.09 ^a
T2		Nitrite 1 hr	55.22±0.91 ^c	24.77±2.82 ^a	23.02±0.79 ^a	1.08±0.20 ^b
T3		Nitrite 24 hr	46.80±1.59 ^b	17.24±0.28 ^b	20.62±1.28 ^{ab}	0.84±0.03 ^b
T4	White	No Nitrite 1 hr	62.08±2.73 ^a	10.96±2.66 ^c	12.23±3.52 ^e	0.97±0.28 ^b
T5		Nitrite 1 hr	61.14±0.60 ^a	17.15±1.25 ^b	16.36±2.01 ^{cd}	0.83±0.26 ^b
T6		Nitrite 24 hr	51.99±2.73 ^b	12.23±1.90 ^c	14.77±1.93 ^{de}	0.79±0.15 ^b
<i>P-value</i> background			<0.001	<0.001	<0.001	0.010
<i>P-value</i> nitrite			<0.001	<0.001	0.013	0.007
interaction			0.535	0.560	0.938	0.138

Note: Mean with different superscript letters a,b,c in the same column indicates significantly differences (P<0.05) L* refer to Brightness, a* refer to Red coloration, b* refer to Yellow coloration

Shrimp stocked in black and white background for 1 and 24 hrs. The results showed that the black background decreased the brightness ($p < 0.05$) but increased the redness (a^*) and yellowness (b^*) of cooked shrimp ($p < 0.05$) including promoting the accumulation of carotenoid in shrimp better than the white background ($p < 0.05$). Hence, the results implied that the background color of tank could reduce the stress of shrimp then maintain carotenoid accumulated in shrimp ($p < 0.05$). Under the nitrite stress condition at 10 ppm for 1 and 24 hr, the cooked shrimp color showed significantly increased ($p < 0.05$) the redness, yellowness after immerge in nitrite for 1 hr compare to no nitrite stress for 1 hr and nitrite stress for 24 hr. The black background demonstrated the better enhancement of red color than the white background condition at every period. Moreover, the combination effects of black background and nitrite stress condition on enhancing cooked shrimp color resulting in increasing the Salmofan score was shown in Figure 1.

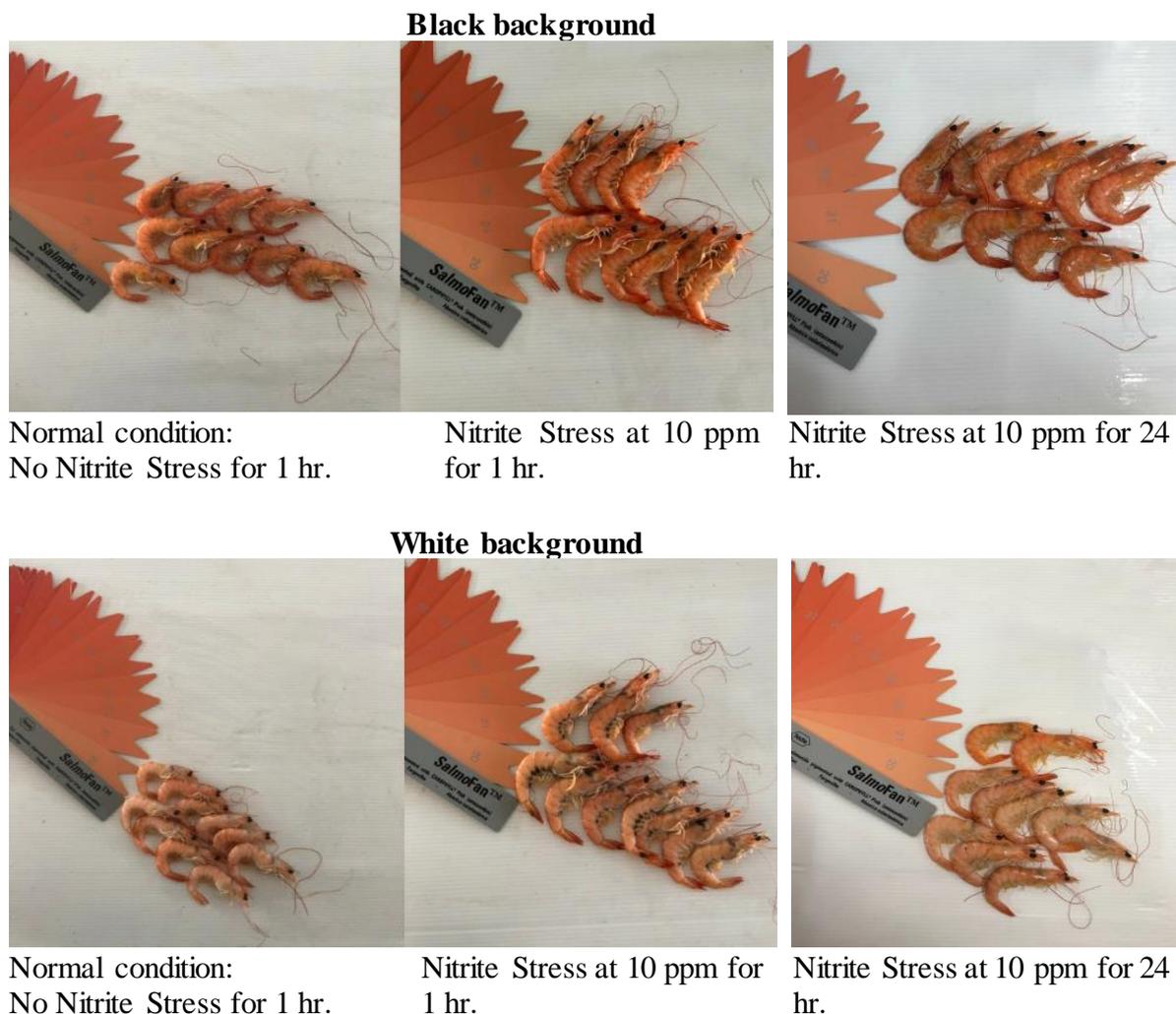


Figure 1: Cooked shrimp (*Litopenaeus vannamei*) color after stocked in black and white background under nitrite stress condition at 10 ppm for 1 hrs.

Carotenoid accumulation in cooked shrimp stock in black background was higher than in white background and decreased after nitrite stress condition in every period. These could imply that shrimp color decreased because carotenoid has been used as antioxidant for reducing free radicals that induced by nitrite stress condition for long time exposure to nitrite for 24 hr then carotenoid accumulation was not enough for color expression. In particular, astaxanthin,

which is the carotenoid form that can express the high red color intensity in cooked shrimp and has powerful antioxidant properties (Kuhn *et al.*, 2010). Astaxanthin was utilized very fast for scavenging free radicals resulting in a lower level of redness.

According to the literature review, shrimp quite be the nocturnal animal, the black background could maintain the redness of cooked shrimp better than the white background due to the reduction of stress. In addition, it is known that shrimp are capable on changing their appearance to blend with background color, through movement of pigment in chromatophores at epidermal layer beneath the exoskeleton (Fingerman, 1965; Robison & Charlton, 1973). Morphological and physiological color changes have been described in crustaceans relating to slow and rapid changes resulting from environmental or hormonal factors (Rao, 1985; Melville-Smith *et al.*, 2003). The movements of pigments in live shrimp may have a direct effect on the color of cooked shrimp (Chien & Jeng, 1992). Nitrite was found to induce shrimp stress, causing many free radicals then shrimp use carotenoid as an antioxidant to eliminate free radicals that occur (Barbieri, *et al.* 2016)., hence, the carotenoids move to the epidermal layer beneath the exoskeleton that cause the increasing of redness and yellowness and effect on decreasing carotenoids accumulation.

Conclusion

The black background condition could promote the cooked shrimp color both in normal condition and under nitrite stress condition better than white background condition. The nitrite stress condition at 10 ppm could enhance the cooked shrimp color in short term periods of 1 hr. better than normal condition. For long term exposure to nitrite stress condition at 10 ppm for 24 hr, the stress condition reduced the redness of cooked shrimp color and reduced the carotenoid accumulation in shrimp.

Acknowledgements

The author would like to thank The Nutrition and Aquafeed Laboratory, Department of Aquaculture, Faculty of Fisheries, Kasetsart University, Bangkok, Thailand for facility and financial support.

References

- Barbieri, E., Bondioli, A. C. V., de Melo, C. B., & Henriques, M. B. (2016). Nitrite toxicity to *Litopenaeus schmitti* (Burkenroad, 1936, Crustacea) at different salinity levels. *Aquaculture research*, 47(4), 1260-1268.
- Chien, Y. H., and Jeng, S. C. (1992). Pigmentation of kuruma prawn, *Penaeus japonicus* Bate, by various pigment sources and levels and feeding regimes. *Aquaculture*, 102(4), 333-346.
- Fingerman, M. (1965). Chromatophores. *Physiol. Rev.* 45, 296–339.
- Kieber, R. J. & P. Seaton (1995). Determination of subnanomolar concentrations of nitrite in natural waters. *Analytical Chemistry* 67(18):3261-3264
- Kuhn, D. D., Smith, S. A., Boardman, G. D., Angier, M. W., Marsh, L., & Flick Jr, G. (2010). Chronic toxicity of nitrate to Pacific white shrimp, *Litopenaeus vannamei*: impacts on survival, growth, antennae length, and pathology. *Aquaculture*, 309(1-4), 109-114.
- Melville-Smith, R., Cheng, Y.W. & Thompson, A.W. (2003). Factors affecting colour change in 'white' western rock lobsters, *Panulirus cygnus*. *Journal of Experimental Marine Biology and Ecology*. 291, 111–129

- Parisenti, J., L.H. Beirão, M. Maraschin & E. R. Oliveira. (2010). Pigmentation and carotenoid content of shrimp fed with *Haematococcus pluvialis* and soy lecithin. *Aquaculture Nutrition* 17(2):e530 - e535
- Ramírez-Rochín, J., Frías-Espericueta, M. G., Fierro-Sañudo, J. F., Alarcón-Silvas, S. G., Fregoso-López, M. G., & Páez-Osuna, F. (2017). Acute toxicity of nitrite on white shrimp *Litopenaeus vannamei* (Boone) juveniles in low-salinity water. *Aquaculture research*, 48(5), 2337-2343.
- Rao, K.R., 1985. Pigmentary effectors, in integuments, pigments and hormonal processes. In: Bliss, D.E., Mantel, L.H. (Eds.), *The Biology of Crustacea*, Vol. 9. Academic Press, New York, pp. 395–462.
- Robison Jr, W.G. & Charlton, J.S. (1973). Microtubules, microfilaments, and pigment movement in the chromatophores of *Palaemonetes vulgaris* (Crustacea). *J. Experimental Zoology* 186, 279–304.
- Tacon, A.G.J., J.J. Cody, L.D. Conquest, S. Divakaran, I.P. Forster & O.E. Decamp. (2002). Effect of culture system on the nutrition and growth performance of Pacific white shrimp, *Litopenaeus vannamei* (Boone) fed different diets. *Aquaculture Nutrition* 8;121-137
- Tomasso, J. R. (2012). Environmental nitrite and aquaculture : a perspective. *Aquaculture international*, 20(6), 1107-1116.
- Steel, R. G. D. & J.H. Torrie. 1980. *Principles and Procedures of Statistics: a biometric approach* (2nd Ed.) Mc Growhill: New York.
- Valencia-Castañeda, G., Vanegas-Pérez, R. C., Frías-Espericueta, M. G., Chávez-Sánchez, M. C., Ramírez-Rochín, J., & Páez-Osuna, F. (2018). Comparison of four treatments to evaluate acute toxicity of nitrite in shrimp *Litopenaeus vannamei* postlarvae: Influence of feeding and the renewal water. *Aquaculture*, 491, 375-380.