Natural Science
ISSN 1859–1388

http://dx.doi.org/10.26459/jns.v126i1B.4261
Vol. 126, No. 1B, 2017, P. 19–28

DEVELOPMENT OF QUALITY INDEX METHOD TO ASSESS FRESHNESS AND SHELF-LIFE OF BLACK TIGER SHRIMP (*PENAEUS MONODON*) STORED AT 0 °C

Le Nhat Tam[1, 2*], Nguyen Nam Giao[1], Tran Thi Ngoc Nhung[1], Dao Bich Duyen[1], Le Thi Hong Nhung[1], Nguyen Ba Thanh[1], Tran Thi Van Thi[2]

[1] Industrial University of Ho Chi Minh City, 12 Nguyen Van Bao St., P.4, Q. Go Vap, Ho Chi Minh City, Vietnam

[2] HU – University of Sciences, 77 Nguyen Hue St., Hue, Vietnam

Abstract: Black tiger shrimps (*Penaeus monodon*) were harvested and stored at 0 °C for study. A quality index method (QIM) developed to evaluate the freshness of black tiger shrimp is presented in this study. The terms used to describe all the changes related to the texture, color, and odor are carefully chosen. The development of the QIM scheme includes three main steps: a preliminary scheme to evaluate all the changes of attributes related to quality; a final QIM scheme and training; and a validation of the QIM scheme and an estimation comparing the remaining shelf-life and the actual shelf-life. The results show that the shelf-life of the black tiger shrimp in the ice storage is 8 days. The quality score involving attributes decreases during the storage time and has a correlation close to the linear regression equation. The scheme of the validation quality of the black tiger shrimp using the QIM method allows the estimation of the remaining shelf life.

Keywords: black tiger shrimp, quality index method

1 Introduction

Nowadays, consumers are interested in high-quality safe and healthy foods [1]. Moreover, in order to secure the food safety, it is necessary to maintain the high quality of seafood in each link of the whole complex chain from catch to consumer [2]. For commercialization, it is essential to estimate accurately its freshness, one of the most important aspects of fish and fish products [3, 4]. Thus, the need for rapid analytical techniques to measure the food quality and freshness is greater than ever. A lot of methods have been evaluated, but sensory method is still used as the most effective technique to assess seafood freshness and quality degradation [5]. Sensory evaluation is the most important method in freshness assessments. Sensory evaluation is defined as the scientific discipline used to evoke, measure, analyze, and interpret reactions to characteristics of food as perceived through the senses of sight, smell, taste, touch, and hearing [6]. There are two types of sensory methods, subjective and objective. Fish freshness is most commonly determined by objective scoring based on organoleptic changes that occur as fish storage time is extended [7]. QIM method is sensory objective method. The QIM, originally developed by the Tasmanian Food Research Unit in Australia [8] and improved further, is consid-

* *Corresponding: tamnhatle@yahoo.com*

Submitted: 13–7–2016; Revised: 12–10–2016; Accepted: 02–3–2017

ered to be rapid and reliable to measure the freshness of whole fish stored in ice [9]. This method is based on significant sensory parameters (skin, eyes, color, texture, odor and the black spots appear on the cuticle and the telson of shrimps) for raw fish [8, 10], and the characteristics listed on the sheet are assessed and appropriate demerit point score is recorded (from 0 to 3). The scores for all characteristics are summed to give the overall sensory score. Quality index (QI) is close to 0 for very fresh fish, whereas higher scores are obtained as the fish deteriorates [16, 26]. During the development of QIM, one of the objectives is to develop a linear correlation between the sensory quality (expressed as the QI) and the storage time in ice, which makes it possible to predict the remaining shelf-life in ice [11–13]. The maximum storage time in ice is defined as the day when the fish is unfit for human consumption. Therefore, the remaining shelf-life (in days in ice) can be calculated on the basis of the correlation between the QI and storage time in ice and information about the quality index corresponding to the time of rejection. Recently developed QIM schemes were presented for raw gilthead sea bream (*Sparus aurata*) [14], farmed Atlantic salmon (*Salmo salar*) [12], fresh cod (*Gadus morhua*) [15], common octopus (*Octopus vulgaris*) [16], herring (*Clupea harengus*) [17]. The advantages of QIM are that it requires short training, is rapid and easy to perform, and is nondestructive and can be used as a tool in production planning and quality warranty work [11].

The aim of this work was to provide all the organoleptic changes of black tiger shrimp in ice storage and develop the QIM scheme evaluation quality for this product.

2 Materials and methods

2.1 Shrimp collection and storage

Black tiger shrimp were harvested fresh from three different farms located in Ca Mau Province – Vietnam. The shrimps with signs of visual defect or breakage were removed. After harvest, the live shrimps were washed in clean filtered flowing water and placed in sterile Reynolds zipper (26.8 cm × 27.9 cm) polyethylene bags (Alcoa Products Inc., Richmond, VA 23261, USA), distributed uniformly in the styrene foam boxes between layers of ice with a shrimps/ice ratio of 1:2 (w/w) and transported to the laboratory after 8 hours. At the laboratory, polyethylene bags containing shrimp samples were kept in a cold room (0 °C) for study. Shrimp sample of day 0 was determined soon after being transferred to the lab.

2.2 Developing QIM scheme method

Developing the terms for description of the changes in attributes of black tiger shrimp stored in ice

The terms describe the changes in attributes related to texture, odor, color of black tiger shrimp collected from observation, and from data of previous researches [18–22]. Descriptive words should be carefully selected, and the panelists trained should agree with the terms. Objective terms should be used rather than subjective terms. It is necessary that the terms used to describe the sensory are short, clear, and understandable for the experts.

Formation and improvement of QIM scheme

Developing a QIM scheme includes three mainly steps.

+ Step 1 – Preliminary scheme: Three experts in sensory evaluation of shrimps observe all changes in quality attributes characteristic (appearance, odor, carapace texture, carapace color, eye, shell color, the black spots appear on the cuticle and the telson of shrimps, etc.) and put them into the preliminary scheme. Each attribute is scored from 0 to 3 with low scores indicating the best quality.

+ Step 2 – Final scheme and training: Shrimp samples were stored at 0 °C and evaluated daily for ten days. There are 6 experts joining in training sessions. The black tiger shrimps stored at different periods of time in ice as previously reported were examined. In this stage, storage time information was provided to panellists for associating the change with the correct time. Next, the evaluation should be performed without knowing the storage period until the evaluation results have been achieved with reliability, accuracy, and precision. The necessary changes in scheme are made.

+ Step 3 – Validation of QIM scheme: Shrimp samples preserved in ice were evaluated according to the QIM scheme, which was developed in step 2. The correlation equation between the storage time and the quality score was developed in this step. Correlation equation was used to determine the remaining shelf-life of shrimps, and to compare with the actual shelf life. The experiments for evaluation of the scheme were performed on 10 different samples.

2.3 Statistical analysis

All measurements were carried out in triplicate. Data were subjected to analysis of variance (ANOVA) using the general linear models procedure of the statistical analysis system software of Statgraphics centurion. Differences among the mean values of the various treatments and storage time were determined using the least significant difference (LSD) test, and the significance was defined at $p < 0.05$.

3 Results and discussion

3.1 The changes of attributes of black tiger shrimp with storage time

The goals are to evaluate the organoleptic changes of shrimps in ice storage, including color, texture, and odor, and other various attributes, as follows:

Color:

+ The order of color changes at the head is: slightly red – bluish – slightly dark – dark

+ The order of color changes at the body is: Bluish white, brightness – Bluish white, and slightly loss of brightness – Slightly red, opaque, and spotted – Reddish, spotted

+ The order of color changes at the tail is: Slightly red – Bluish – Slightly dark – Dark

+ The order of color changes at the meat is: Pearly white – Lime colored – Slightly pinkish – Pinkish or light yellow

Texture:

+ The order of texture changes at the appearance is: Shape intact, head firmly attached to body → shape intact, head slightly attached to body where tissues around neck → flesh loosely attached to shell, head loosely attached to body remain loose → flesh loosely attached to shell, head very loosely attached to body

+ The order of texture changes at the meat is: Hard → slightly soft → soft → very soft

Odor:

+ The order of odor changes at the shrimps is: Fresh → seaweed → slight or no odor → sour

The problem of discoloration is one of the most serious concerns of the seafood industry. The discoloration is usually due to black spot development, also called melanosis. Melanosis is the harmless but unappealing surface discoloration on shrimps, crabs or lobsters and is caused by the enzymatic oxidation of colorless phenols into quinones (Fig. 2), which undergo non-enzymatic polymerization generating dark insoluble pigments [23].

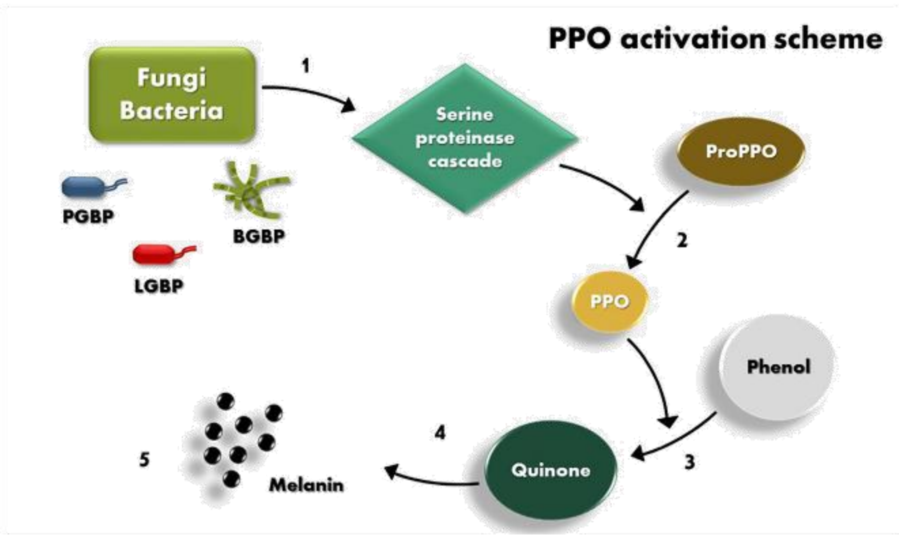

Fig. 1. Melanin formation due to PPO activation scheme on crustaceans [24]

Yellow discoloration is due to the migration of carotenoid pigments from chromatophore or carotenoprotein complexes in the skin to the subcutaneous fat layers. The oxidation of carotenoid pigments also results in fading of the pink or red color of fish flesh or skin when stored in ice or at chilling temperature [25]. Suyama and Konosu [26] reported that softening due to the collagen layer is destroyed. Moreover, fish and shellfish muscles also contain less connective tissue than those of mammals and thus, the cross-links formed by their collagens are not as extensive. All these factors contribute to an enhanced rate of fish and shellfish flesh softening. The tenderization or flesh softening is considered to be associated with the disappearance of Z-disks, dissociation of actomyosin complex, destruction of connection, and general denaturation of collagenous tissue [27, 28].

3.2 QIM scheme for sensory evaluation of black tiger shrimp

For this current study, the sensory characteristics (color, texture and odor) and (parts of) sample, with subsequent description and scores, are shown in Table 1.

Table 1. QIM scheme for sensory evaluation of black tiger shrimp (*Penaeus monodon*)

Characteristics		Description	Score
Color	**Head**	Bright pink, no spots	0
		Bright blue–green, no spots	1
		Blue–green or slight dark, moderately spots	2
		Dark	3
	Body	Blue–green, brightness and iridescent	0
		Grey–greenish, loss of brightness and slightly opaque	1
		Brownish red, opaque, moderately spots	2
		Dark	3
	Tail	Bright pink, no spots	0
		Bright blue–green, no spots	1
		Blue–green or slight dark, moderately spots	2
		Dark	3
	Meat	Pearly white	0
		lime color	1
		Slightly pinkish	2
		Pinkish or light yellow	3
Texture	**Appearance**	Shape intact, head firmly attached to body	0
		Shape intact, head slightly attached to body where tissues around neck	1
		Flesh loosely attached to shell, head loosely attached to body remain loose	2
		Flesh loosely attached to shell, head very loosely attached to body	3
	Meat	Hard, elastic texture	0
		Slightly soft, loss of elastic	1
		Moderately soft	2

		Soft and watery texture	3
Odor	**Odor**	Fresh	0
		Sea weed	1
		Slightly or no odor	2
		Sour	3

3.3 Organoleptic changes of black tiger shrimp stored in ice

The changes in organoleptic attributes with storage time has been quantified, as depicted in Table 2.

Table 2. Organoleptic changes, QI and grade of black tiger shrimp undergoing storage in ice

Storage days	Description	QI	Grade
0	Bright pink head and tail, blue–green body, bright and iridescent shell. Fresh pearly white, hard and elastic meat, shape intact, head firmly attached to body, fresh odor.	0.93	Excellent
1	Bright pink head and tail, blue–green body, bright and iridescent shell. Fresh pearly white, hard and elastic meat, shape intact, head firmly attached to body, fresh odor.	1.53	
2	Bluish head and tail, blue–green body, slight loss of body brightness, iridescent, fresh pearly white, hard and elastic meat, shape intact, head firmly attached to body, fresh odor.	3.67	Very good
3	Bright blue–green head and tail, grey-greenish body, slight loss of brightness and slightly iridescent, fresh meat with characteristics lime color, hard and elastic; shape intact, head firmly attached to body, fresh odor.	5.60	
4	Bright blue–green head and tail, slightly spot, grey-greenish body, slightly spots, loss brightness and slightly opaque; fresh meat with characteristics lime color, loss elastic and slightly soft; shape intact, head slightly attached to body where tissues around neck; odor of seaweed.	7.47	Good
5	Blue–green head and tail, moderately spot, grey-greenish body, slightly spots, loss of brightness and slightly opaque; fresh meat with characteristics of lime color, loss of elastic and slightly soft; shape intact, head slightly attached to body where tissues around neck; odor of seaweed.	9.53	
6	Blue–green head and tail, grey-greenish or brownish red body, moderate spots, no brightness, moderately opaque, slightly pink meat, moderately soft; flesh loosely attached to shell, head loosely attached to body, neutral odor.	11.37	Acceptable
7	Blue–green or slightly dark head and tail, grey-greenish or brownish red body, moderate spots, no brightness, moderately opaque, slightly pinkish meat, moderately soft, flesh loosely attached to shell, head loosely attached to body, neutral odor.	12.93	

8	Slightly dark head and tail, brownish red body, moderate spots, no brightness, opaque, pinkish meat, soft; flesh loosely attached to shell, head loosely attached to body, slightly sour odor	14.43	Moderately acceptable
9	Dark head and tail, slight body spots, yellow meat, soft; flesh loosely attached to shell, head loosely attached to body, sour odor.	15.93	Rejected
10	Dark head and tail, dark body, spots. Yellow meat, soft and watery texture; flesh loosely attached to shell, head loosely attached to body, sour odor.	16.93	

The changes of organoleptic qualities of black tiger shrimp can be classified into six phases corresponding to the periods of 0 to 1, 2 to 3, 4 to 5, 6 to 7, 8, and 9 to 10 days storage in ice; the phases are denoted as I to VI, respectively. In phase I, the shrimps just passed the rigor mortis and did not change in texture and color. The quality of shrimps was excellent with QI from 0.93 to 1.53. In phase II, organoleptic characteristics of shrimps were similar to those of phase I, nevertheless there was a slight change in color of head and tail with QI from 3.67 to 5.60. In phase III, there was a slight loss of brightness, and the body became slightly opaque. Fresh slightly soft, less elastic meat with the characteristics of lime color, and there were a few spots on head and tail. The quality of shrimps was good with QI from 7.47 to 9.53. In phase IV, there was a lot of color change in head and tail; they were slightly dark; the head loosely attached to the body. The body was slightly reddish and moderately opaque with moderate spots. The slightly pinkish, soft flesh loosely attached to the shell. The quality of shrimps was acceptable with QI from 11.37 to 12.93. In phase V, the organoleptic characteristics were the same as those in phase IV, but the meat was pinkish and began to have slightly sour odor. The quality of shrimps was moderately acceptable with QI of 14.43. In phase VI, the organoleptic characteristics of shrimps became unacceptable. The quality of shrimps was categorized as rejected with QI from 15.93 to 16.93. Thus, our results showed that the shelf-life of shrimps stored in ice was 8 days. Some researchers evaluated the fresh seafood quality using a sensory method, showing that the shelf-life of ice storage black tiger shrimp was from day 8 to day 10 [18, 22, 29], and the shelf-life of ice storage Pacific white shrimps was 8 days [30]. The organoleptic changes of black tiger shrimp with the storage time are shown in Fig. 2. In general, the QI increases with the storage time, and the increase is significant with $p < 0.05$. The regression equation has the form: $y = 1.7139x + 0.5546$ ($R^2 = 0.9938$). Martinsdóttir [5] also reported that the Quality Index increased linearly with the storage time of fish in ice.

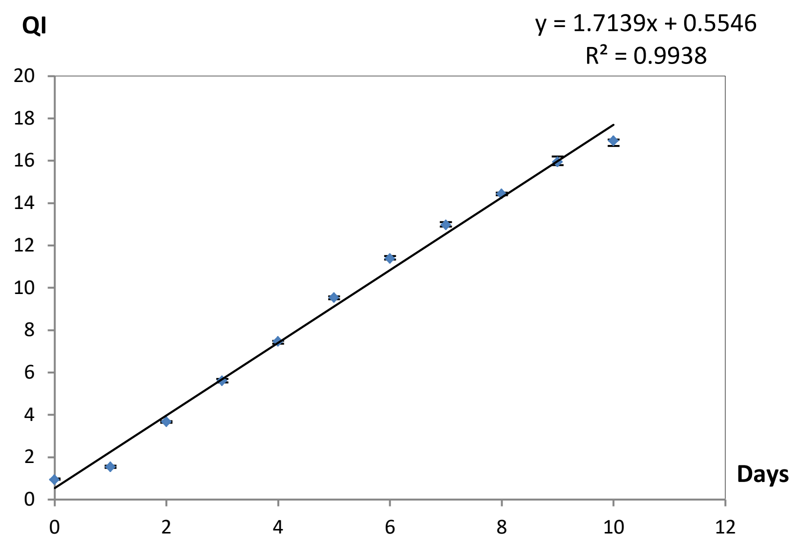

Fig. 2. Changes of QI of black tiger shrimp in ice during 10 days

3.4 Validation of QIM scheme for black tiger shrimp

The Table 3 shows the results the actual and postulated shelf-life values actually based on the calculated equation.

Table 3. Validation of QIM scheme by estimated shelf-life and actually remaining shelf-life

Sample	QI	Equivalent number of days storage in ice	Estimated shelf-life according to QIM scheme	Actually remaining shelf-life
Sample 1	3.22	1.5	6.5	6.2, 6.3, 6.6
Sample 2	1.77	0.7	7.3	7.2, 7.4, 7.3
Sample 3	5.89	3.1	4.9	4.8, 5.1, 5.2
Sample 4	9.76	5.4	2.6	2.4, 2.7, 2.8
Sample 5	6.32	3.4	4.6	4.5, 4.7, 4.7
Sample 6	12.67	7.1	0.9	0.8, 0.8, 1.0
Sample 7	4.72	2.4	5.6	5.5, 5.7, 5.8
Sample 8	8.59	4.7	3.3	3,4, 3.5, 3.4
Sample 9	11.35	6.3	1.7	1.8, 1.9, 2.2
Sample 10	10.45	5.7	2.3	2.0, 2.2, 2.4

The resulting validation shows that the estimated remaining shelf-life of the experimental samples had a significant difference (p < 0.05) compared with the actually remaining shelf life. The values of actually remaining shelf-life were close to the remaining shelf-life calculated from the regression equation, and this results demonstrated that our QIM scheme can be used to evaluate the freshness and to classify the shrimp quality.

4 Conclusion

The assessment of quality and shelf-life of black tiger shrimp (*Penaeus monodon*) freshly harvested and stored at 0 °C was presented in this paper. The shelf-life of the shrimps was determined to be 8 days under the storage condition using the quality index method developed in this paper. In the response to the increase in the demand for information about the quality and freshness by the consumers and growth of economy commerce, the quality index method appears to be an easy, rapid and efficient tool to assess the storage history and estimate the remaining shelf-life of black tiger shrimp specifically and seafood generally. The new quality index method can be used to combine chemical quality indices for freshness to create a complete program evaluation of black tiger shrimp.

Reference

1. Sen D. (2005), *Advances in fish processing technology,* Vol. 1. Allied Publishers.
2. Hyldig G., Green-Petersen D.M. (2004), Quality Index Method—an objective tool for determination of sensory quality, *Journal of aquatic food product technology*, **13**(4) 71–80.
3. Olafsdottir G. (1997), Methods to evaluate fish freshness in research and industry, *Trends in Food Science & Technology*, **8**(8) 258–265.
4. Huidobro A. (2001), Washing effect on the quality index method (QIM) developed for raw gilthead seabream (*Sparus aurata*), *European Food Research and Technology*, **212**(4) 408–412.
5. Martinsdóttir E., Bremner H. (2002), Quality management of stored fish, *Safety and quality issues in fish processing*, 360–378.
6. Huss H. H. (1995), *Quality and quality changes in fresh fish*, FAO fisheries technical paper, 348.
7. Connell J., Shewan J. (1980), *Sensory and non-sensory assessment of fish*. in *Advances in fish science and technology: papers presented at the Jubilee conference of the Torry Research Station, Aberdeen, Scotland, 23–27 July 1979, edited by JJ Connell and staff of Torry Research Station,* Farnham, Surrey, England, Fishing News Books.
8. Bremner H. (1985), *A convenient, easy to use system for estimating the quality of chilled seafoods.* Fish Processing Bulletin,.
9. Botta J. R. (1995), *Evaluation of seafood freshness quality*, John Wiley & Sons.
10. Branch A., Vail A. (1985), Bringing fish inspection into the computer age, *Food Technology in Australia*, **37**(8) 352–355.
11. Hyldig G.,Nielsen J. (1998), *A rapid sensory method for quality management*, in *Methods to determine the freshness of fish in research and industry*., IIR.
12. Sveinsdottir K. (2003.), Quality Index Method (QIM) scheme developed for farmed Atlantic salmon (*Salmo salar*), *Food Quality and Preference*, **14**(3) 237–245.
13. Luten J., Martinsdottir E. (1997), QIM: a European tool for fish freshness evaluation in the fishery chain..

14. Huidobro A., Pastor A., Tejada M. (2000), Quality index method developed for raw gilthead seabream (*Sparus aurata*), *Journal of Food Science*, **65**(7) 1202–1205.
15. Bonilla A. C., Sveinsdottir K., Martinsdottir E. (2007), Development of Quality Index Method (QIM) scheme for fresh cod (*Gadus morhua*) fillets and application in shelf life study, *Food control*, **18**(4) 352–358.
16. Barbosa A. Vaz-Pires P. (2004), Quality index method (QIM): development of a sensorial scheme for common octopus (*Octopus vulgaris*), *Food Control* **15**(3) 161–168.
17. Nielsen D., Hyldig G. (2004), Influence of handling procedures and biological factors on the QIM evaluation of whole herring (*Clupea harengus L.*), *Food research international*, **37**(10) 975–983.
18. Hanpongkittikun A., Siripongvutikorn S., Cohen D. L. (1995), Black tiger shrimp (*Penaeus monodon*) quality changes during iced storage, *Asean Food Journal (Malaysia)*,.
19. Azam K., Alam S. N., Naher S. S. (2010), Quality assessment of farmed black tiger shrimp (*Penaeus monodon*) in supply chain: Organoleptic evaluation, *Journal of Food Processing and Preservation*, **34**(s1) 164–175.
20. Archer M. (2010), Sensory assessment score sheets for fish and shellfish-Torry & QIM, *Edinburgh: Seafish*.
21. TCVN 3726–89,*Tôm nguyên liệu tươi, Fresh shrimps for food processing*, 3726–3789.
22. Liên D. T. P. (2011), Đánh giá nhanh độ tươi tôm sú nguyên liệu (*Penaeus monodon*) bảo quản trong nước đá (0–4^{o}c) theo phương pháp chỉ s ố chất lượng QIM, *Tạp chí Khoa học* ,: p. 10.
23. Nirmal N. P.,Benjakul S. (2011), Inhibition of melanosis formation in Pacific white shrimp by the extract of lead (*Leucaena leucocephala*) seed, Food chemistry, **128**(2) 427–432.
24. Gonçalves A. A., Oliveira A. R. M. (2016), Melanosis in crustaceans: A review, *LWT–Food Science and Technology*, **65**, 791–799.
25. Haard N. (1992), *Biochemistry and chemistry of color and color change in seafoods*, , Technomic Publishing Co. Inc., Lancaster and Basel.
26. Suyama M., Konosu A. (1987), Postmortem changes of fish and shellfish, *Marine Food Science (Suison Shokuhin-Gaku)*,.
27. Koohmaraie M. (1988), Role of Ca^{++}-Dependent Proteases and Lysosomal Enyzmes in Postmortem Changes in Bovine Skeletal Muscle, *Journal of Food Science*, **53**(5) 1253–1257.
28. Koohmaraie M., Schollmeyer J., Dutson T. (1986), Effect of Low-Calcium-Requiring Calcium Activated Factor on Myofibrils under Varying pH and Temperature Conditions, *Journal of Food Science*,. **51**(1) 28–32.
29. Jayaweera V., Subasinghe S. (1990), *Some chemical and microbiological changes during chilled storage of prawns (Penaeus indicus)*, FAO Fisheries Report (FAO).
30. Okpala, C.O.R., W.S. Choo, and G.A. Dykes (2014), Quality and shelf life assessment of Pacific white shrimp (Litopenaeus vannamei) freshly harvested and stored on ice, *LWT–Food Science and Technology*,. **55**(1), 110–116.