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A quality index method for squid *Uroteuthis (Photololigo) chinensis* L. (Gray, 1849) preserved on ice

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Abstract:
Uroteuthis (Photololigo) chinensis L. is one of the most popular kind of seafood that accounts for about 20% of all cephalopod species caught in Vietnam. This study was aimed at developing a quality index method (QIM) scheme to assess the quality and freshness of Loliginid squids. The new method will be of benefit to consumers, fishers, seafood dealers, seafood industry businesses, and controlling entities. The QIM scheme for Loliginid squids was based on the changes registered for 10 sensory parameters, scoring from 0 to 28. The obtained equation for linear correlation with *P*-value < 0.05 during storage was $Y = 1.083\,X_{tg} + 2.866$, with coefficient $R^2 = 0.99$. When preserved on ice, the Loliginid squids proved to have a shelf life of 10–12 days. The QIM program and the quality index equation provided a user-friendly, quick, and efficient scientific-based tool that can specify the storage time and estimate the remaining shelf life for Loliginid squids. The scheme can be combined with other chemical quality parameters of freshness to form a full quality assessment program for Loliginid squids.

Keywords: Squid, *Uroteuthis (Photololigo) chinensis*, sensory properties, QIM, ice storage

INTRODUCTION

Uroteuthis (Photololigo) chinensis L. belongs to Cephalopods, one of the most popular seafoods in the world. Currently, the annual yield of *Uroteuthis (Photololigo) chinensis* in Vietnam is estimated at 110 000 tons, accounting for over 20% of total squids caught in Vietnam [1]. Cephalopods have no bones, which means that an average Loliginid squid has from 80 to 85% of edible parts, whereas teleosts have 40–75%, crustaceans – from 40–45%, and cartilaginous fish – only 25% [2]. Loliginid squids are associated with a wide range of dried, frozen, chilled, canned, and ready-made products.

Nowadays, consumers pay special attention to high quality and healthy food [3]. To ensure seafood safety, producers have to maintain the product quality on each step of the whole supply chain, from fishing net to fork [4]. The phase between fishing and processing facilities is of high importance because seafood is typically stored on ice, and its quality deteriorates quickly. Therefore, it is necessary to find a quick and effective method to evaluate the seafood freshness quality during this phase.

When seafood undergoes protein degradation during storage, the sequence of changes can be detected by human senses. Sensory evaluation is

an easy and effective method of seafood freshness assessment for its economic properties. Sensory evaluation is a scientific method to measure, analyze, and explain the sensory responses as perceived by the senses of sight, smell, taste, touch, and hearing [5]. There are many modern sensory assessment methods to evaluate seafood quality, e.g. the EU-scheme, the quality index method (QIM), the Torry scale, and the quantitative descriptive analysis method [6]. In Vietnam, the sensory properties of Loliginid squids are typically evaluated using the descriptive method and scoring according to the Vietnamese National Standards No. TCVN 3215-79 and TCVN 5652-1992 [7–9]. There is a need to develop a compliance quality control to world standards to help the Vietnamese seafood standards reach the world-class level.

The QIM is a quick and reliable way to measure the freshness of cold storage seafood [10, 11]. The QIM method is based on the prespecified meaning of the seafood parameters, e.g. skin, mucus, eyes, belly, smell, etc. Each parameter scores from 0 to 3. The quality index is the total score. When the quality index approaches 0, the seafood is considered fresh, while a higher quality index means some degree of quality deterioration [5]. The quality index increases linearly during ice storage time and is used for quality control in seafood processing. The QIM is developed and applied individually to every seafood species [10, 12].

All squids demonstrate sensory changes during storage: they depend on the species, assessment method, fishing area, season, time of fishing, and storage conditions. There were several studies worldwide to evaluate the sensory changes of squids using QIM applied to individual kinds of squids, e.g. common cuttlefish (*Sepia officinalis* L.), southern shortfin squids (*Illex coindetii* L.), and common octopus (*Octopus vulgaris* L.) [13, 14]. Still, there have been no similar studies on Loliginid squids (*Uroteuthis (Photololigo) chinensis*).

Therefore, consumers, fishers, seafood traders, seafood industry businesses, and controlling entities need a reliable tool to determine the quality and freshness of Loliginid squids. This study proposes a sensory evaluation program based on the QIM scheme for Loliginid squids preserved on ice.

STUDY OBJECTS AND METHODS

The research involved fresh *Uroteuthis (Photololigo) chinensis* L. obtained from Cat Ba fishing port, Hai Phong City, Vietnam, in August 2019.

The squids were layered on a plastic tray with holes and a stainless steel cap. The set was put in an insulated icebox with the squid/ice ratio of 1:2 (w/w) and transported to the Laboratory of Research Institute for Marine Fisheries. In the laboratory, the insulated perforated bottom icebox was kept in the refrigerator at 0–4ºC. Ice was added to the boxes as required. The samples were taken every day, from day 0, when the

samples were at their freshest, to day 25, when they got spoilt.

The terms to describe the changes in the sensory parameters related to the texture, smell, and color came from direct observation of the samples, previous studies, and the Vietnamese National Standards No. TCVN 11182-2015 and TCVN 5652-1992 [7, 13, 14]. An expert committee selected the descriptive terms via discussion and agreement. The terms were short, clear, commonly used, and easy to understand. The members of the committee were chosen and trained according to TCVN 12388-2: 2018.

The establishing of the quality index method (QIM) scheme included three steps:

Step 1 – Establishing the initial scheme. Three to five experts observed all the changes in each of the following quality parameters: skin, flesh, and eye color; flesh structure; belly and mouth area smell; eye and tentacle status; and surface and mouth mucus. After that, they developed the terms for the initial scheme. Each property received a score from 0 to 3; a lower score indicated a better quality.

Step 2 – QIM scheme and committee training. The samples were stored at 0–4°C and were evaluated daily during the 25-day period. The committee consisted of six experts. During this phase, the committee members were initially aware of the time of storage to be correlated with the changes of properties during storage. During further phases, the members received no information regarding the storage time of the sample until the results became accurate and reliable.

Step 3 – Applying the QIM scheme. Ten squid samples were evaluated using the QIM scheme established during step 2 (from Mo1 to Mo10). The correlation formula between storage time and quality index helped to estimate the storage time and the remaining shelf life. The estimation was then compared to reality.

The collected data were analyzed using the descriptive statistic method (average, standard deviation). ANOVA 1 factor (P-value < 0.05) made it possible to determine the difference of the factors in the experiments using the Statgraphic XV and MS Excel software. Each test was performed in triplicate and repeated three times with similar results.

RESULTS AND DISCUSSION

The aim of this step was to evaluate the changes in the sensory parameters of *Uroteuthis (Photololigo) chinensis* L. stored on ice. The parameters included color, texture, smell, etc. After that, the terms were selected to describe the changes to be used in the quality index method (QIM) scheme.

The color was assessed according to the state of the skin, meat, and eyes of the squids. Figs. 1–3 show the color changes in the skin, meat, and eyes of the squids.

The skin was translucent on day 0; translucent white, with black pigment spots on day 5; midly

Day 0   Day 5   Day 15   Day 20

Figure 1 Changes in the skin color during storage

Day 0   Day 10   Day 15   Day 25

Figire 2 Changes in meat color during storage

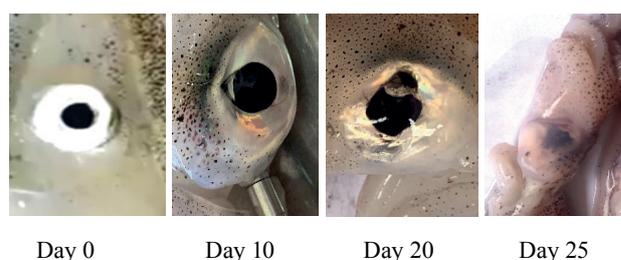Day 0   Day 10   Day 20   Day 25

Figure 3 Changes in color and status of squid eyes during storage

opalescent white, with pink spots, slightly reddish on day 15; and red, with blurry purple-red pigment spots on day 20 (Fig. 1). The meat was described as translucent white on day 0; mildly opalescent white on day 10; pearly white on day 15; and opalescent white, milky white on day 25 (Fig. 2). Changes in the eyes were as foolows: translucent on day 0; mildly opalescent on day 10; opalescent on day 20; and milky white with black fluid on day 25 (Fig. 3).

Smell: property changes and terms. The smell was assessed on the body and mouth area. The changes of the odour on the squid body were described as: seaweedy, fresh, or seafood smell (day 0); mildly fishy (day 10); strongly fishy, mildly sour (day 20); and heavily fishy, foul, spoiled (day 25). The changes of the smell on the mouth areas were seaweedy, fresh, seafood smell (day 0); seaweed, mildly fishy (day 5); strong fishy (day 10); strong fishy, mildly foul (day 15); and heavily fishy, foul, spoiled, respectively (day 25).

Texture and status: property changes and terms. The status or structure assessment was based on the structure of flesh, status of the eyes, texture of the mucus on the body, mouth, and condition of the tentacles.

The structure of the flesh was described as consistent, well elastic (day 0); consistent, elastic (day 5); less elastic, slightly soft (day 15); and flaccid, viscous (day 25).

The shape of the eyes was described as convex, round pupils (day 0); less convex, less round pupils (day 5); flat eyes, pupils not rounded (day 15); and eyes slightly concaved, pupil ruptured (day 20).

The textures of the mucus on the body were transparent (day 0); Transparen, viscous, thin layer (day 5); less sticky, watery (day 10); less sticky, watery (day 15), and none (day 20).

The textures of the mucus on the mouth area were transparent (day 0); transparent, stick (day 5); and little and yellowish (day 20).

The tentacles were changed as consistent, strong sucking, suckers intact (day 0); soft, could not suck when touched, suckers start to fall out (day 10); and flaccid, not sucking, suckers falling out (day 15).

QIM scheme for sensory evaluation of Loliginid squids. In this study, we established a QIM scheme for Loliginid squids. It included 10 parameters and recorded the sensory changes during storage time with a score from 0 to 28 (Table 1).

Changes in the Loliginid squid stored on ice. Table 2 features the changes in the sensory parameters of Loliginid squids that occurred during storage.

The Loliginid squids demonstrated obvious changes in the sensory quality during ice storage. It could be divided into four levels: days 0–5, days 5–10, days 10–15, and days 15–25. The levels were numbered from I to IV, respectively. At level I (days 0–5), the squids were raw and fresh, and there was no change in the texture, color, or smell. Most of the sensory parameters scored 0, and the quality index did not exceed 10. At level II (days 5–10), the sensory parameters started to change: the body color and the smell of body and mouth area scored from 0 to 1 with the quality index at about 10–15. At level III (days 10–15), there were apparent changes in the sensory parameters: the skin lost its shine, pinkish pigment spots appeared, the flesh became opalescent, and the smell increased. Most of the sensory parameters got 1–2 scores, and the quality index fluctuated from 15–20, showing that the squids started to deteriorate. At level IV (> 15 days), the sensory parameters changed: the whole body reddened, patchy dark pigment

Table 1 QIM scheme for sensory evaluation of *Uroteuthis (Photololigo) chinensis* L.

Parameters		Description	Score
Color	Skin	Translucent color	0
		Translucent white, with black pigment spots	1
		Mildly opalescent white, pink spots, slightly reddish	2
		Pink, red, with blurry purple-red pigment spots	3
	Flesh	Translucent white	0
		Mildly opalescent white	1
		Pearly white	2
		Opalescent white, milky white	3
	Corneal/eye tissues	Translucent	0
		Mildly opalescent	1
		Opalescent	2
		Milky white with black fluid	3
Smell	Body	Seaweedy, fresh, or seafood smell	0
		Mildly fishy	1
		Strongly fishy, mildly sour	2
		Heavily fishy, foul, spoiled	3
	Mouth area	Seaweedy, fresh, seafood smell	0
		Mildly seaweed fishy	1
		Fishy, mildly foul	2
		Heavily fishy, foul, spoiled	3
Status	Flesh structure	Consistent, highly elastic	0
		Consistent, elastic	1
		Less elastic, soft	2
		Flaccid, viscous	3
	Eye shape	Convex, round pupils	0
		Less convex, less round pupils	1
		Flat eyes, pupils not rounded	2
		Slightly concaved, pupil ruptured	3
	Body mucus	Transparent	0
		Transparent, sticky, thin layer	1
		Less sticky, watery	2
		Not detected	3
	Mouth mucus	Transparent	0
		Transparent, sticky	1
		Poor and yellowish	2
	Tentacles	Firm, strong sucking, suckers intact	0
		Soft, could not suck when touched, suckers start to fall out	1
		Flaccid, not sucking, suckers falling out	2
	Range of QIM score		0–28

appeared, the flesh became floppy, and the foul smell became strong. Most parameters scored 2–3, showing clear signs of spoilage. The deterioration became especially evident on days 20–25: the whole body became purple-red and started to emanate a strong foul smell, while the flesh was flaccid and viscous. Therefore, the shelf life for squids preserved on ice equaled 10–12 days.

Figure 4 shows changes in the sensory parameters of Loliginid squids stored on ice. The quality index demonstrated a meaningful linearly increase over time with $P < 0.05$.

The recession equation was: $Y = 1.083 X_{tg} + 2.866$ ($R^2 = 0.9908$).

Verifying the QIM scheme for Loliginid squids. Table 3 sums up the results of determining storage time and remaining shelf life of squids using the equation (*) and real remaining time.

In this study, we established a QIM scheme that fully described the sensory changes that occurred in *Uroteuthis (Photololigo) chinensis* according to their biochemical transformation during ice storage. The scheme involved such parameters as skin and pigment color, flesh and mucus texture, and body and mouth smell. Pink color often appears on the cephalopod bodies. Skin pigments deter Loliginid iorate easily as a result of oxidation and enzyme tyroprotease during the storage period, and the skin goes black, pink, or red [15–17]. The flesh texture softens mostly due to the endogenous protease [18, 19].

Table 2 Changes in sensory parameters of *Uroteuthis (Photololigo) chinensis* L. during ice storage

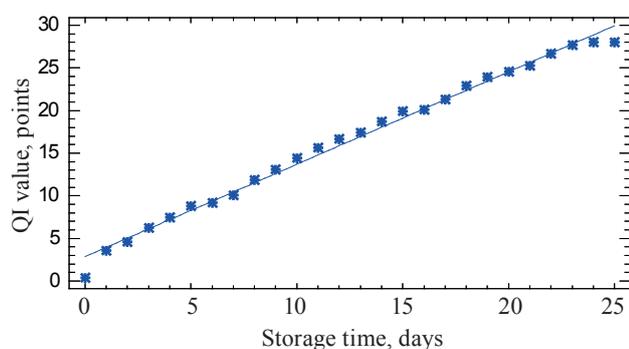| Storage time, days	Sensory parameters	Quality index	Level
0	Translucent body, seaweedy, fresh, or seafood smell; firm, consistent, well elastic flesh; convex eyes, round translucent pupils; translucent mucus; firm, well sucking tentacles with intact suckers	0.39 ± 0.50	I
5	Translucent white body, with black pigment spots; seaweedy smell; mildly opalescent white and firm flesh; less convex eyes, less round black pupils; translucent mucus; rather soft tentacles with intact suckers but not sucking.	8.83 ± 0.71	II
10	White body with clear pigment spots, mildly fishy smell, white and firm flesh; mildly convex eyes with opalescent not rounded pupils; some mucus remains; rather soft tentacles with suckers starting to fall out, no sucking	14,44 ± 0,51	II
15	Mildly opalescent white body with some pink pigment spots, reddish skin; strong fishy and mildly foul smell; pearly white flesh, soft and less elastic; flat eyes with mildly opalescent corneal, not rounded pupils; less mucus remains; soft tentacles with suckers fallen out.	19.89 ± 0.47	III
20	Pinkish body with reddish pigment spots all around the body; strong fishy, foul smell; opalescent white soft flesh; mildly concaved eyes with opalescent corneal, broken pupils; no mucus; flaccid tentacles with suckers completely fallen out.	24.56 ± 0.51	IV
25	Purple-pink body with pigment spots all over; foul smell; milky white, soft and viscous flesh; mildly concaved eyes with opalescent corneal, broken pupils; no mucus; flaccid tentacles with suckers completely fallen out.	28.00 ± 0.00	IV

Figure 4 Quality index changes in the Loliginid squids during ice storage

Table 3 Determining storage time and estimating the remaining shelf life of squids during ice storage using QIM scheme

Sample	Quality index	Storage time based on the equation, days	Estimating the remaining shelf life based on the equation, days	Real remaining time, days
Mo1	4.13	1.17	10.83	10.30 ± 0.26
Mo2	6.54	3.40	8.60	8.17 ± 0.36
Mo3	11.21	7.72	4.28	4.77 ± 0.25
Mo4	16.43	12.56	–0.56	–
Mo5	9.15	5.81	6.19	5.80 ± 0.26
Mo6	12.46	8.88	3.12	3.33 ± 0.58
Mo7	13.57	9.91	2.09	2.630 ± 0.32
Mo8	18.74	14.69	–2.69	–
Mo9	5.36	2.31	9.69	9.93 ± 0.12
Mo10	14.89	11.13	0.87	0.83 ± 0.29

We concluded that the shelf life of Loliginid squids was 10–12 days, which is equivalent to and slightly longer than that of other squid species in the previous QIM studies. For instance, raw cuttlefish and shortfin squids proved to have 9–10 days of shelf life, while that of common octopus was only 8–10 days [13–15, 20].

The quality index equation introduced in this article correlated with the reports from previous authors that the quality index value increased linearly during ice storage in various kinds of seafood, e.g. fish, shrimps, and octopus [12, 15, 21, 22]. The verifying result also showed that the real remaining shelf life was similar to the calculated one. Therefore, the developed equation proved to be a scientifically based tool that could be used to evaluate the freshness and quality of raw Loliginid squids.

The obtained QIM scheme and quality index equation set a new quality control standard for the Loliginid squid in Vietnam. As they are simple enough to be used on the international seafood market, they also contribute to the QIM schemes that can be used worldwide.

CONCLUSION

In this study, we successfully established a quality index method (QIM) scheme for sensory evaluation of *Uroteuthis (Photololigo) chinensis* L. stored on ice. The scheme included ten parameters, and the quality index value was 0–28. We also developed a linear correlation equation of quality index and storage time with $R^2 = 0.99$. The best shelf life for Loliginid squids stored on ice proved to be from 10 to 12 days. The QIM and quality index equation can be combined with other chemical quality parameters of freshness to form a full-quality assessment program for Loliginid squids. The program could provide a user-friendly, quick, and efficient scientific-based tool that could help customers, fishers, seafood traders, seafood industry businesses, and controlling entities to specify the storage time and estimate the remaining shelf life for Loliginid squids.

CONTRIBUTION

The idea behind the analysis belongs to B.T.T. Hien. B.T.T. Hien, P.T. Diem, P.V. Tuyen, N.V. Thanh, D.V. An, L.A. Tung, N.K. Bat, N.V. Nghia, and N.T.M. Tu collected the data. B.T.T. Hien, P.T. Diem, P.V. Tuyen, and H.-D. Tran contributed data and performed the analysis. B.T.T. Hien, P.T. Diem, N.K. Bat, and H.-D. Tran wrote the paper. All the authors proof-read the manuscript and agreed to its published version.

CONFLICT OF INTEREST

The authors declare no conflict of interests related to

REFERENCES

1. Nguyen VN. Overall survey of fluctuations in marine resources in Vietnam's seas, period (2011–2015). Project final report of Research Institute for Marine Fisheries. 2016. (In Vietnamese).

2. Sauer WH, Gleadall IG, Downey-Breedt N, Doubleday Z, Gillespie G, Haimovici M, et al. World Octopus Fisheries. Reviews in Fisheries Science and Aquaculture. 2019. DOI: https://doi.org/10.1080/23308249.2019.1680603.

3. Fox M, Mitchell M, Dean M, Elliott C, Campbell K. The seafood supply chain from a fraudulent perspective. Food Security. 2018;10(4):939–963. DOI: https://doi.org/10.1007/s12571-018-0826-z.

4. Hyldig G, Green-Petersen DMB. Quality Index Method – an objective tool for determination of sensory quality. Journal of Aquatic Food Product Technology. 2005;13(4):71–80. DOI: https://doi.org/10.1300/J030v13n04_06.

5. Caliman BF, Ene C. Sensory evaluation in food manufacturing: practical guidelines. In: Jean-Vasile A, editor. Food science, production, and engineering in contemporary economies. Pennsylvania: Hershey; 2016. pp. 294–314 DOI: https://doi.org/10.4018/978-1-5225-0341-5.ch012.

6. Hassoun A, Karoui R. Quality evaluation of fish and other seafood by traditional and nondestructive instrumental methods: Advantages and limitations. Critical Reviews in Food Science and Nutrition. 2017;57(9):1976–1998. DOI: https://doi.org/10.1080/10408398.2015.1047926.

7. Le DT. Research to optimized the seafood post-harvest preservation technology. Project Final report of Research Institute for Aquaculture II. 2005. (In Vietnamese).

8. Nguyen XT. Research the preservation technology for products on offshore trawlers. Project final report of Research Institute for Marine Fisheries. 2015. (In Vietnamese).

9. Dang VA. A model research of Loliginid squids preservative technology on offshore trawlers in Thai Binh Province. Project final report of Research Institute for Marine Fisheries. 2019. (In Vietnamese).

10. Diler A, Genc IY. A practical quality index method (QIM) developed for aquacultured rainbow trout (*Oncorhynchus mykiss*). International Journal of Food Properties. 2018;21(1):857–866. DOI: https://doi.org/10.1080/10942912.2018.1466326.

11. Freitas J, Vaz-Pires P, Camara JS. Freshness assessment and shelf-life prediction for *Seriola dumerili* from aquaculture based on the quality index method. Molecules. 2019;24(19). DOI: https://doi.org/10.3390/molecules24193530.

12. Solanki J, Parmar H, Parmar A, Parmar E, Masani M. Freshness evaluation of fish by quality index method (QIM) and instrumental method at veraval fish landing centre. International Journal of Processing and Post harvest Technology. 2016;7(1):42–46. DOI: https://doi.org/10.15740/HAS/IJPPHT/7.1/42-46.

13. Vaz-Pires P, Seixas P. Development of new quality index method (QIM) schemes for cuttlefish (*Sepia officinalis*) and broadtail shortfin squid (*Illex coindetii*). Food Control. 2006;17(12):942–949. DOI: https://doi.org/10.1016/j.foodcont.2005.07.004.

14. Barbosa A, Vaz-Pires P. Quality index method (QIM): development of a sensorial scheme for common octopus (*Octopus vulgaris*). Food Control. 2004;15(3):161–168. DOI: https://doi.org/10.1016/s0956-7135(03)00027-6.

15. Shalini R, Shakila RJ, Jeyasekaran G, Jeevithan E. Sensory, biochemical and bacteriological properties of octopus (*Cistopus indicus*) stored in ice. Journal of Food Science and Technology. 2015;52(10):6763–6769. DOI: https://doi.org/10.1007/s13197-015-1751-1.

16. Andouche A, Bassaglia Y. Coleoid cephalopod color patterns: adult skin structures and their emergence during development in sepia officinalis. Vie Et Milieu – Life and Environment. 2016;66(1):43–55.

17. Zavadlav S, Lackovic I, Kovacevic DB, Greiner R, Putnik P, Filipec SV. Utilizing impedance for quality assessment of European squid (*Loligo Vulgaris*) during chilled storage. Foods. 2019;8(12). DOI: https://doi.org/10.3390/foods8120624.

18. Bastos P, Fracalossi DM, Chimal ME, Sanchez A, Rosas C. Digestive enzymes and timing of digestion in *Octopus vulgaris* type II. Aquaculture Reports. 2020;16. DOI: https://doi.org/10.1016/j.aqrep.2019.100262.

19. Slama-Ben Salem R, Bkhairia I, Abdelhedi O, Nasri M. Octopus vulgaris protein hydrolysates: characterization, antioxidant and functional properties. Journal of Food Science and Technology. 2017;54(6):1442–1454. DOI: https://doi.org/10.1007/s13197-017-2567-y.

20. Sykes AV, Oliveira AR, Domingues PM, Cardoso CM, Andrade JP, Nunes ML. Assessment of European cuttlefish (*Sepia officinalis*, L.) nutritional value and freshness under ice storage using a developed Quality Index Method (QIM) and biochemical methods. LWT – Food Science and Technology. 2009;42(1):424–432. DOI: https://doi.org/10.1016/j.lwt.2008.05.010.

21. Tam LN, Giao NN, Nhung TTN, Duyen ĐB, Nhung LTH, Thanh NB, et al. Development of Quality Index Method (QIM) to assess the freshness and shelf-life of black tiger shrimp (*Penaeus monodon*) stored at 0°C. Hue University Journal of Science: Natural Science. 2017;126(1B):13–22. DOI: https://doi.org/10.26459/hueuni-jns.v126i1B.4261.

22. Duong TPL, Bui TQH, Nguyen BL. Quick evaluation the freshness of raw tiger prawns (*Penaeus monodon*) preserved on ice (0–4°C) using QIM methods. Can Tho University Journal of Sciences. 2011;18:53–62. (In Vietnamese).

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