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Quality index method to evaluate the quality of Jinga shrimp (*Metapenaeus affinis* L.) preserved in ice water

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Abstract:
The Quality Index Method (QIM) provides a quick and accurate quality assessment. It makes it possible to calculate preserving time and establish the freshness of sea food. This article introduces a quality assessment program based on the QIM scheme and quality index (QI) for the Jinga shrimp.
The research included Jinga shrimps (*Metapenaeus affinis* L.), a commercially valuable aquatic species widely distributed throughout the Vietnamese coast. The input data included the changes in appearance and sensory profile of sampled shrimps during 20 days of storage at 0–4°C in ice water.
They were used to construct a QIM scale, which was applied to other shrimp samples at different storage time to evaluate the relationship between the QI score and the storage time. After that, the QIM scale was tested on ten random shrimp samples to verify its shelf-life predictive power. This study managed to establish a correlation equation between the QI scores and the storage time with the coefficient of R_2= 0.97. This correlation proved highly reliable as verified by comparing the predicted and actual best shelf life of Jinga shrimps stored in ice water for 8–10 days.
The QIM program provides a practical and effective science-based tool that delivers fast and reliable results for customers, fishermen, food traders, and aquacultural enterprises.

Keywords: Jinga shrimp, sensory evaluation, quality index method, storage time, ice storage, shelf life

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INTRODUCTION

Consumers assess food products according to their sensory properties [1, 2]. Sensory evaluation is necessary to commercialize a food product. It is especially important for seafood, since freshness is the most important aspect of fisheries and aquaculture products [3, 4]. Wholesalers often use ice water to store shrimps in fishing vessels or processing facilities. However, the quality of fresh aquatic raw materials, especially raw shrimps, degrades very quickly during storage. Therefore, all stakeholders need a quick and efficient method to assess the freshness of aquatic products.

Sensory assessment is a scientific method used to evoke, measure, analyze, and interpret sensations that are perceived through sight, smell, taste, touch, and hearing [5]. For marine seafood, sensory assessment is fast, cheap, and effective. The list of contemporary aquatic sensory assessment methods includes the EU-scheme, the Quality Index Method, and the Torry Sensory Analysis [6]. The Quality Index Method (QIM) is an especially fast and reliable means of measuring the freshness of seafood [7, 8]. QIM tests the significant levels of such attributes as skin, slime, eyes, abdomen, smell, etc. of aquatic products. These attributes are indicated in the table of assessment guidelines with scores from 0 to 3. Quality Index (QI) is the total score. If the QI value is close to zero, the product is considered fresh, whereas a higher QI value indicates that the product has degraded. Each aquatic species has its own QIM [9, 10]. QIM has an obvious advantage over the conventional classification method commonly used for seafood raw materials: the QI is the sum of all attribute variations. As a result, food scientists can establish a linear relationship between the QI score and the ice-preserving time, thereby estimating the storage period [11, 12].

Shrimps go through a number of physical and chemical transformations from catch to death. These processes cause sensory changes in appearance, texture, and color during the storage period. Discoloration is a common phenomenon in aquatic products. In shrimps, suboptimal preservation might cause immediate black spots called melanosis. This phenomenon was first reported in 1951 [13]. Originally, scientist attributed melanosis to the activity of microorganisms although today it is concluded to be the oxidation of polyphenoloxidase enzymes in shrimp and crabs [14, 15]. In shrimps, the color depends on the close connection between pigments and proteins. This association makes shrimps shiny blue while alive. When boiled, shrimps turn reddish pink. When shrimps are alive, astaxanthin pigment exists in the form of a protein bond that creates the characteristic color. When shrimps die, this bond weakens and disappears under the impact of temperature and light, separating from the protein and creating a new red color [16].

Many contemporary studies apply QIM to evaluate the transformation of sensory quality in Northern shrimps (*Pandalus borealis* L.), white-leg shrimps (*Lipopenaeus vannamei* L.), and giant tiger prawns (*Penaeus monodon* L.) [17–22].

Jinga shrimps (*Metapenaeus affinis* L.) are harvested by shrimp trawls. In Vietnam, Jinga shrimps are widely distributed throughout the North-South coast [23]. Jinga shrimps have a water content of 77–79% and lipids of 1–2%, which is higher than in other shrimp species. These two characteristics affect the spoiling process, thus, requiring appropriate post-harvest preservation methods [24]. Considering the importance of maintaining the quality, we developed a program using the quality index method to evaluate the sensory quality transformation of the Jinga shrimp (*M. affinis*) during ice-water storage.

STUDY OBJECTS AND METHODS

Study objects. This study introduces a new program that applies the Quality Index Method (QIM) to the sensory assessment of Jinga shrimps (*Metapenaeus affinis* L.) during ice water storage.

Research materials. The research involved fresh Jinga shrimps, 30–35 shrimps/kg, harvested near Do Son at Hai Phong Port, the biggest port city in Northern Vietnam, in October 2019 and November 2020.

The shrimps were stored in insulated ice crates with a shrimp/ice ratio of 1:2 (w/w) and transported to the Marine Science Laboratory of the Seafood Research Institute (Hai Phong, Vietnam). There, the shrimps were put into plastic boxes, which were filled with ice up to the ratio of 1:2 (w/w) and water up to the ice surface. The boxes were kept in a refrigerator at 0–4°C. Ice supplements and water withdrawal were made every two days. Samples for analysis and sensory evaluation were taken daily, from fresh (day 0) until spoiled (day 20).

Methodology. ***Methodology for developing the QIM program for Jinga shrimps.***

Developing terms to describe changes in sensory profile of shrimps stored in ice water. Panelists were selected and trained according to TCVN 12388-2:2018 Sensory analysis – General guidance for the staff of a sensory evaluation laboratory – Part 2: Recruitment and training of panel leaders. The terms to describe the changes in texture, smell, and color were collected from direct observation of the study samples and from previous studies (TCVN 11182:2015 Sensory analysis – Vocabulary, TCVN 12614:2019 Frozen – Black tiger, Vannamei shrimp) [20–22, 25]. The trained panelists selected the terms by extensive discussion. According to the selection criteria, the terms were to be concise, clear, familiar, and easy to understand.

Formulating and developing the QIM scheme for Jinga shrimps. The QIM program included the following steps:

Step 1. Preliminary program: three to five experts of the Seafood Research Institute were tasked to observe and record all changes in quality attributes (color and structure of head, legs, and body; meat texture; smell) and set the terms in the preliminary program. Each attribute was scored from 0 to 3, with the lowest score for the best quality.

Step 2. QIM program and panel training: the shrimps were stored at 0–4°C and evaluated daily for 20 days. The shrimps were stored at different intervals in ice, as described in Section 2.1. Six experts participated in the training sessions for the panelists. During the training, the panelists received the information on the storage time to associate the attribute changes with the time. Next, they performed the assessment without information about the storage time to guarantee reliable and accurate evaluation results.

Step 3. Practicing the QIM program: the panelists collected ten samples of Jinga shrimps (samples T_{01}–T_{10}) stored in ice water and evaluated them according to the QIM program, as described in Step 2. The correlation equation between the storage time and the quality score was used to determine the stored time and the remaining shelf life of the shrimps to be compared with the actual storage shelf life.

Quality index (QI) scoring method. The method of calculating QI followed the procedure described in [26]. The quality index was calculated according to the following Eq. (1):

$$\text{QI} = \frac{\sum_{i=1}^{n}\left(QI_1 + \ldots + QI_n\right)}{n} \sum_{k=1}^{m}\left(t_1 + \ldots + t_m\right) \quad (1)$$

where QI was the sensory quality index (average total sensory quality score); QI_1,..., QI_n stood for the total sensory quality score of each member of the evaluation board; n denoted the number of panelists; i was the number of the panelist; m was the number of shrimp attributes recorded in the QIM table (m depends on the species); t denoted the number of sensory scores of the panelist for each shrimp attribute; and k_1... k_m were shrimp attributes.

Data analysis methods. The data collected were analyzed using descriptive statistics (mean, standard deviation). The difference in the factors between the modal tests was analyzed by ANOVA 1 factor ($p < 0.05$) using the Statgraphic XV software and the Excel software. Each experiment was conducted three times, resulting in an average of total experiments.

RESULTS AND DISCUSSION

Results of recording the transformation and selection of terminology according to the storage time. The goal of the research was to document the changes in the sensory properties of Jinga shrimps stored in ice, including color, texture, smell, etc. Preference belonged to the terms with the highest frequency of occurrence in a given period.

Term selection results for smell. The shrimp smell changed at different stages.

Stage 1 (days 0–4). The shrimps still retained the characteristic fresh smell described as "the smell of the sea", with a high frequency of occurrence > 80% (Fig. 1). After this period, the shrimp smell began to change.

Stage 2 (days 4–8). Most samples were reported to have a slightly fishy smell of seaweed.

Stage 3 (days 8–14). The shrimps smelled fishy or of weak ammonia. The unmistakable fishy smell was more frequent, but both descriptions appeared for a long time and in the same period. Both descriptions were found fit to describe the shrimp smell at this stage.

Stage 4 (days 14–20). The clear ammonia and putrid odor clearly indicated that the shrimps went bad.

The terms selected to describe the smell of shrimps ranked as follows: characteristic fresh shrimp smell → smell of seaweed/mild fishy → clear fishy/mild ammonia → clear ammonia/putrid.

Term selection results for color. *Shrimp head color.* The shrimp head color change occurred in four stages (Fig. 2):

Stage 1 (days 0–2). The color was almost unanimously described as a clear and shiny yellow. The description of a bright, pink color (< 5%) was not selected due to the low frequency, and it was registered only on day 0.

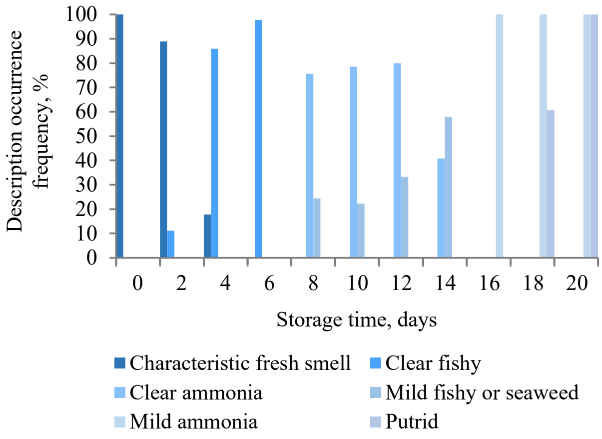

Figure 1 Frequency of shrimp smell descriptions by storage time

Stage 2 (days 2–8). The two most frequent descriptions included a less clear color (light yellow) and reduced gloss (> 80%).

Stage 3 (days 8–14). The shrimp heads were described as pale pink-orange. This description had a high frequency and appeared on many days. Black grey also was reported during this period; however, its frequency was low.

Stage 4 (days 14–20). The shrimp heads were orange-pink, black, grey, orange, and orange-red. The descriptions were persistent and appeared during the spoilage stage.

The terms selected to describe the color of shrimp heads ranked as follows: clear color (yellow)/shiny → less clear color (light yellow)/reduced gloss → pale orange pink → clear orange-pink, orange, orange-red, black grey.

Shrimp body color. Figures 3 demonstrates the color variation of the shrimp body:

Stage 1 (days 0–2). The color remained clear and shiny. The green dots on the body were distinct.

Stage 2 (days 2–10). The shrimp body color became less clear; the gloss decreased, and the green dots on the body grew slightly faded.

Stage 3 (day 10–16). The shrimp body turned orange; the dots became faint.

Stage 4 (days > 16). The body lost its color and turned dark orange; the green dots became blurred, and black spots started to appear.

Multiple descriptions were selected for each stage to provide a detailed description of shrimp body. The terms depicting the color variation of shrimp body were selected as follows: shiny clear color, green dots on the body are distinct → color is less apparent; gloss is reduced (slightly shine); green dots are slightly blurred → appear orange-pink/orange starts to appear; green dots are slightly blurred, with tiny black dots → clear orange-pink/dark orange; the green dots are blurred; many large, clear black spots start to appear.

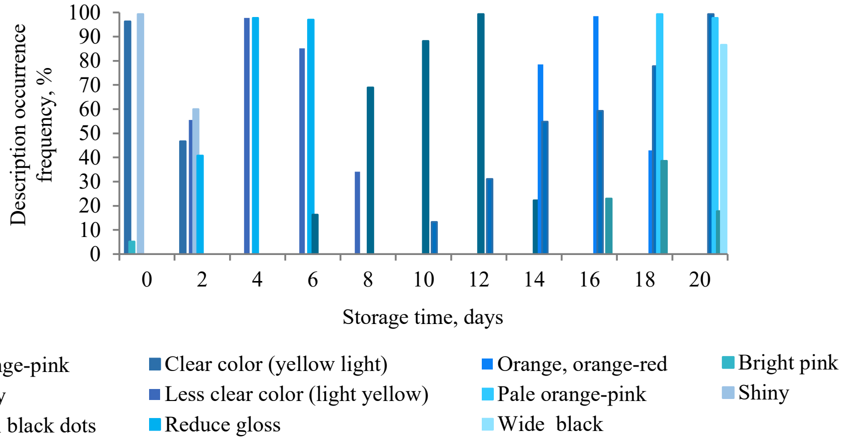

Figure 2 Frequency of shrimp head color descriptions by storage time

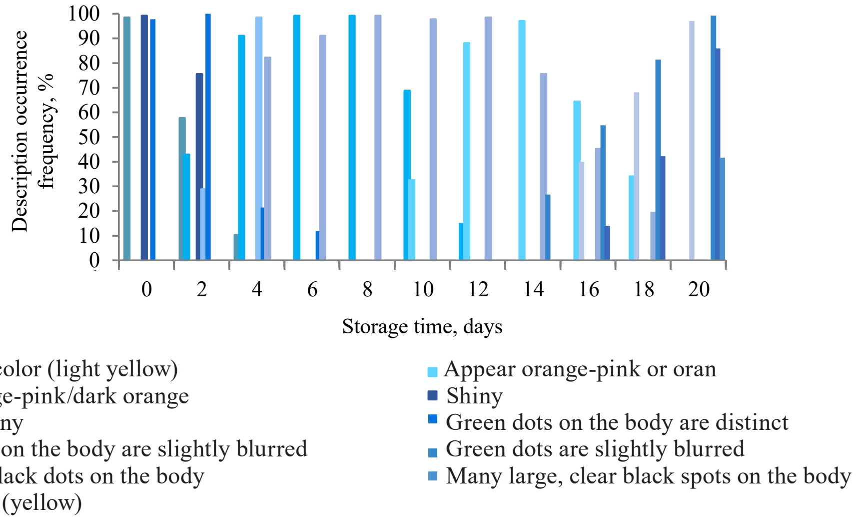

Figure 3 Frequency of shrimp body color descriptions by storage time

Shrimp leg color. Figure 4 shows the color terms that depict the changes in shrimp legs:

Stage 1 (days 0–2). The legs were bright yellow.

Stage 2 (days 2–8). The yellow color grew lighter (> 60%).

Stage 3 (days 8–14). The shrimp legs showed signs of blackening.

Stage 4 (days 14–20). They turned black.

The terms to describe the change in the color of the shrimp legs were selected as follows: bright orange-yellow → pale orange-yellow → signs of turning black black.

Shrimp meat color. Figure 5 shows the terms that be the color of shrimp meat in four stages:

Stage 1 (days 0–4). The shrimp meat was delicate white (> 60%).

Stage 2 (days 4–10). The meat lost its translucency and turned white.

Stage 3 (days 10–16). The meat was opaque white.

Stage 4 (days 16–20). The shrimp meat was pale yellow or pale pink, and small black spots started to appear.

The terms to describe the changes in the color of shrimp meat ranked as follows: translucent white/transparent → loss of clarity, turning white → opaque white → pale pink, pale yellow, with some small black spots.

Term selection results for structure/state. *Shrimp head structure*. Figure 6 shows the way shrimp head structure changed with storage time:

Stage 1 (days 0–4). The shrimp heads were intact and firmly attached to the bodies; all the samples got this description with a very high frequency.

Stage 2 (days 4–6). The heads began to show signs of loosening from the body (> 70%).

Stage 3 (days 6–16). The shrimp heads began to loosen, with signs of tomalley dilution.

Stage 4 (days 16–20). The shrimp heads demonstrated crushed tomalley and fell off.

The terms to describe the structure of shrimps were selected as follows:intact; head fastened to body intact, signs of loosening → tomalley dilution → crushed tomalley, head off.

Shrimp body structure. The term depicts the four stages of body structure transformations (Fig. 7):

Stage 1 (days 0–4). The shrimp body was intact from, and the abdomen segments were firmly attached (> 80%).

Stage 2 (days 4–8). the shrimps showed signs of loosening (> 50%), along with firmly attached abdomen segments.

Stage 3 (days 8–14). one to two abdomen segments loosened; the term appeared with a high frequency of occurrence.

Stage 4 (days 14–20). the shrimps loosened in most segments; this description increased in occurrence frequency.

The terms to describe the state of the shrimp body were selected as follows: intact, firmly attached segments → signs of slight loosening in 1–2 segments → loosening in most abdomen segments.

Shrimp meat texture. Figure 8 shows the terms that describe the textural change in shrimp meat:

Stage 1 (days 0–4). the shrimp meat was described as firm and elastic, with high frequency (> 80%).

Stage 2 (days 4–10). the meat was still elastic (> 50%), followed by the description of less elastic and soft meat. The shrimp meat in this period began to transform and was not as good as at Stage 1.

Stage 3 (days 10–16). the meat was described as less elastic, which showed a reduction in the shrimp meat quality.

Stage 4 (days 16–20). The meat lost its elasticity and gained softness and flaccidity (> 60%).

The terms to describe the changes the shrimp meat texture were selected as follows: firm, elastic → elastic → slow elastic and soft → not elastic, soft and flaccid.

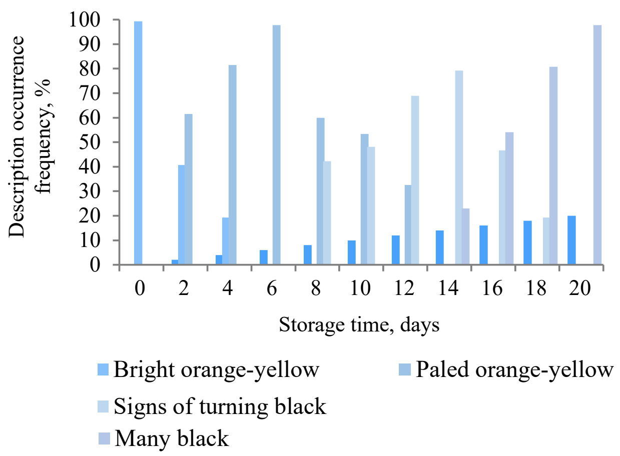

Figure 4 Frequency of shrimp leg color descriptions by storage time

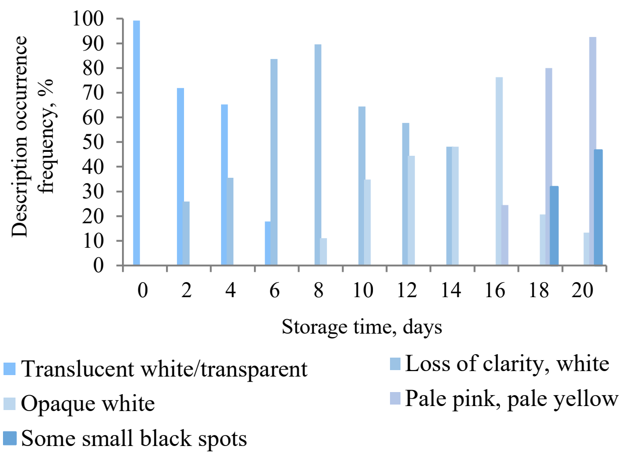

Figure 5 Frequency of shrimp meat color descriptions by storage time

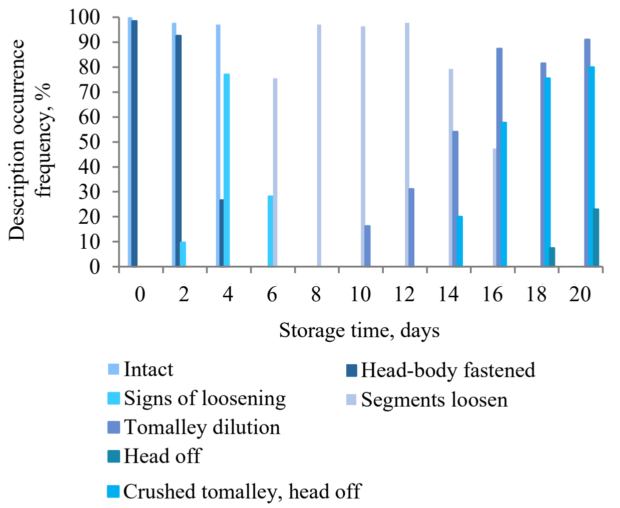

Figure 6 Frequency of shrimp head structure descriptions by storage time

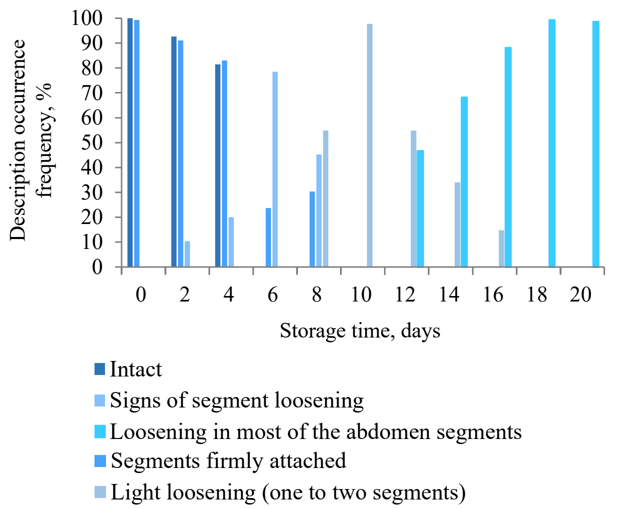

Figure 7 Frequency of shrimp body structure descriptions by storage time

Shrimp shell status. Figure 9 illustrates the frequency of terms selected to depict the transformation of shrimp shells:

Stage 1 (days 0–4). The shells were described as shiny, hard, and firm, tightly attached to the meat;

Stage 2 (days 40–14). The shells grew slightly tender and started loosening from the meat; and

Stage 3 (days 14–20). The shell became soft and loosely attached to the meat.

The terms to describe the shrimp shells selected ranked as follows: shiny, hard shells; firmly attached shell and meat → slightly soft shells; meat and shells not firmly attached → soft shells; shells loosen from meat.

Figure 10 illustrates the changes in the overall appearance of the shrimps during 20 days of storage in ice water.

QIM program for shrimp sensory evaluation. Table 1 shows scores from 0 to 3 that marked the changes in sensory properties of different parts of shrimp body. The QIM scheme was based on nine attributes observed to have changed during storage: smell; color of the head, body, and legs; body and head status; meat texture. These nine attributes were included in the QIM assessment program with scores from 0 to 26 points: QI = 0 corresponded to the best quality shrimps, and QI = 26 corresponded to the lowest quality possible.

The QIM scheme (Table 1) was designed to assess the sensory quality of Jinga shrimps preserved in ice water. Compared to the QIM program developed for giant tiger prawns and white-leg shrimps, the attributes of Jinga shrimps were different in terms of head and

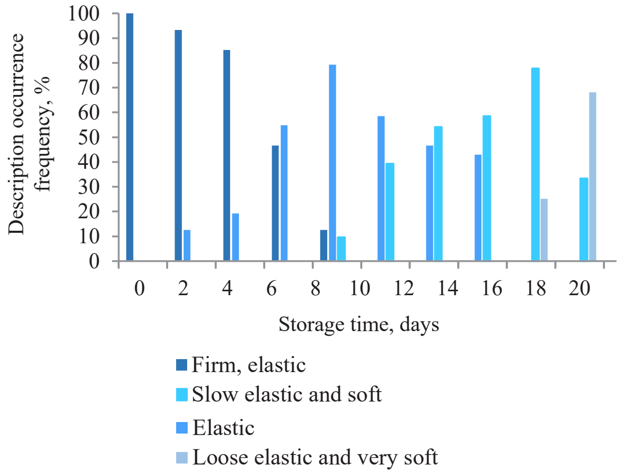

Figure 8 Frequency of shrimp meat texture descriptions by storage time

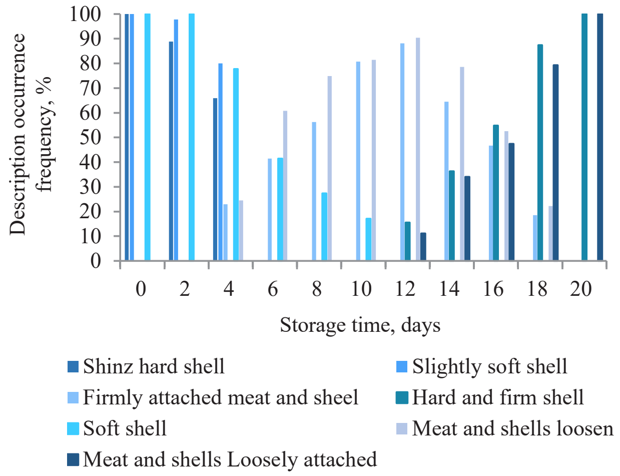

Figure 9 Frequency of shrimp shell descriptions by storage time

Figure 10 Transformations on shrimps stored in ice water for 20 days

Table 1 QIM Scales for Jinga shrimps (*Metapenaeus affinis* L.)

Attributes		Descriptions	QI
Smell		Characteristic fresh shrimp smell	0
		Seaweed smell, mild fishy	1
		Clear fishy, mild ammonia	2
		Clear ammonia, putrid	3
Shrimp Head	*Color*	Clear color (yellow light), shiny, translucent, visible inner organs	0
		Less clear color (light yellow); orange-pink appears; poor gloss	1
		Color changes into clear orange-pink, black-grey, or brown; opaque, with a few small black spots	2
		Light orange, orange-red, with wide black areas	3
	State	Intact; head fastened to body	0
		Intact; signs of segment loosening	1
		Loose segments; tomalley dilution	2
		Crushed tomalley; head falls off; loose segments	3
Shrimp body	*Color*	Clear color (yellow light), shiny, translucent; distinct green dots	0
		Light yellow, slightly shiny, with no black spots; slightly blurred green dots	1
		Discolored, orange-pink or dark orange; a few small black spots; blurred green dots	2
		Complete discoloration, dark orange-pink, black-grey	3
	State	Intact; firmly attached segments	0
		Intact; slightly loosened segments	1
		One to two loose segments	2
		Most segments are loose	3
Shrimp Legs	*Color*	Bright orange-yellow	0
		Pale orange-yellow	1
		Pale yellow-orange, signs of blackening	2
		Black	3
Shrimp shell status		Shiny, hard, and sturdy; firmly attached to meat	0
		Slightly soft; starts loosening from meat	1
		Soft, loose from meat	2
Shrimp meat	*Color*	Translucent white	0
		Clear, white	1
		Opaque, white	2
		Opaque white, pale pink, and pale yellow, with some small black spots	3
	Texture	Good elasticity, firm	0
		Elastic	1
		Soft, low elasticity	2
		Not elastic, soft and flaccid	3
Total			26

body color, leaning toward yellow, orange, and black. In terms of smell, ammonic smell grew clear over time. The color of giant tiger prawns changes from blue to green and the smell grows sour at the end of shelf life. White-leg shrimps change from grey to green and emit an unmistakable smell of trimethylamine, as reported by Le *et al.* [22, 25]. Thus, each type of shrimp has different sensory variations depending on the species and habitat, and each of them needs a tailored QIM scheme.

Results of developing the correlation equation between QI and storage time for Jinga shrimps. Table 2 sums up the changes in the sensory properties of Jinga shrimp's over preserving time.

The temporal transformations were consistent with the terminology developed by the panelists, and the progress of the changes was apparent over time. On day 2, the shrimps had almost the same properties as on day 0, thus keeping the original value; the head color and the shell gloss reduced but not significantly. On day 4, the shrimps developed evident changes: a fishy smell, dull color, opaque white meat, loose segments, etc. On day 6, the properties associated with freshness were almost gone: the heads turned orange, the meat grew white, the shell loosened from the meat, and the head separated from the body. On day 8, the shrimps began to show signs of deformation: the head turned orange or pink-orange while the legs turned black; the shell grew soft, and the meat and the shells started to loosen. On day 10, the shrimps developed a smell of ammonia, and the tomalley started to dilute while the head and body segments loosened. On days 12–20, the shrimps showed obvious signs of spoilage and emitted a robust putrid smell. We observed discoloration of the whole shrimp body, appearance of black spots, complete body segment loosening, and shell softening. The meat turned from poorly elastic to soft pasty, the head fell off the body, and the tomalley diluted to watery.

Table 2 Sensory changes and QI of shrimp stored in ice water

Day	Expression of sensory properties	QI score	Remarks
0	The characteristic fresh scent, or "the smell of the sea". The head and body of the shrimp have a clear light-yellow color, and shiny, transparent flesh; body segments are firmly attached. The shell is sturdy and rigid. The meat and shell are firmly attached. The shrimp is firm and elastic.	^{a}	Most sensory attributes get 0 points
2	Shrimps retain their characteristic fresh scent, or "the smell of the sea". The state remains almost original; the head color and gloss are not significantly reduced.	$7.5^{b} \pm 0.51$	Most sensory attributes get 1 point
4	The shrimp smell is slightly fishy, like seaweed. Its head, body, and leg color are light yellow, and the gloss reduces. The shrimp meat loses its clarity and begins to turn white. The shrimp shows signs of loosening on the head and some body segments. The shrimp shell does not change much, and the meat remains firm and elastic.	$9.78^{c} \pm 0.55$	Most sensory attributes get 1 point
6	The shrimp smells slightly fishy, like seaweed. Its head starts to turn orange, while the body and legs go pale. The meat turns white. The head segment loosens, with signs of body segment loosening. The shell feels soft. The meat and shell do not attach firmly.	$11.72^{d} \pm 0.46$	Most sensory attributes get 2 points
8	The shrimp smell is fishy. The legs are pale orange, with signs of blackening. The meat is white. The head segment loosens, and one or two body segments start to loosen. The shell feels soft. The meat and shell do not attach firmly. The meat is still elastic but not as good as it used to be.	$13.39^{e} \pm 0.78$	Most sensory attributes get 2 points
10	The shrimp has a fishy, mild ammonia smell. The head is pale pink-orange, with the dilution of tomalley. The body is pale yellow. The legs show signs of blackening. The meat is white. The head segment and one to two body segments loosen. The shell feels soft. The meat and shell do not attach firmly; the meat is still elastic.	$16.17^{f} \pm 0.51$	Most sensory attributes get 2 points
12	The shrimp starts to emit a mild smell of ammonia. The head color is pink-orange; the tomalley is diluted. The body turns pale orange, and the green dots are slightly blurred. The leg color is dark and turns black. The meat is white. The head and body segments loosen. The shell is slightly soft. The meat and the shell are not firmly attached. The flesh starts to lose elasticity and becomes slightly soft.	$19.17^{g} \pm 0.51$	Most sensory attributes get 2 points
14	The shrimp emits ammonic smell. The head goes apparent orange-pink, accompanied by black-grey. The body turns pale orange, and the green dots are slightly blurred. The legs are black. The meat is white. The head loosens, and the tomalley dilutes. Segment loosening happens all over the body. The shell is slightly soft, and the meat and the shell are not firmly attached. The meat is soft and slowly elastic.	$20.83^{h} \pm 0.86$	Most sensory attributes get 2–3 points
16	The ammonic smell is clear. The head and body are completely discolored. The flesh is opaque white or slightly pale pink. The head segment loosens, and the tomalley dilutes. Whole body segments loosen. The shrimp shell is slightly soft; the meat and the shell are not firmly attached. The meat is soft and slowly elastic.	$20.56^{i} \pm 0.51$	Most sensory attributes get 2–3 points
18	The shrimp starts to smell putrid. Small black spots appear on the body. The legs are black. The meat is pale pink and yellow, with some small black spots. The head falls apart, and the tomalley dilutes. Whole body segments loosen. The shell grows soft. The meat and the shell are loosely attached. The meat is not elastic, but soft and flaccid.	$23.33^{k} \pm 0.91$	Most sensory attributes get 2–3 points
20	The shrimp is thoroughly spoiled and smells rotten and putrid. The head color appears clear orange with broad black areas; the body is orange, grey, or black, and the legs are black. The meat is opaque white, pale yellow, or pale pink. The tomalley is crushed, and the head falls apart. All body segments loosen. The shell is soft. The meat and the shell are loosely attached. The meat is not elastic, but soft and flaccid.	$26.0^{m} \pm 0.0$	Most sensory attributes get 3 points

$^{a, b, c,..., m}$ – represent the statistically significant difference of QI values between the dates; TGBQ stands for storage time

The results in Table 2 show that QI increased with storage time, and the increase was significant with $p < 0.05$. The regression equation takes the following Eq. (2):

$$Y = 1.16\text{Xtg} + 4.32 \; (R^2 = 0.97) \; (*) \qquad (2)$$

Other researchers also reported that the quality index (QI) increases linearly with the storage time in ice water in seafood, giant tiger prawns, and white-leg shrimps [10, 20, 22, 25]. Figure 11 illustrates the correlation between the shrimp quality scores and the storage date.

The graph shows the linear relationship and the proportional correlation between storage time and QI score with $p < 0.05$ and angle coefficient a > 0. Based on Table 3, Jinga shrimps stored in ice water should be consumed within 8–10 days when the QI is still < 18

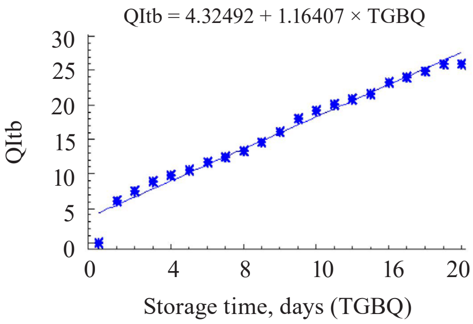

Figure 11 Linear correlation between QI score and shrimp storage time in ice water

points. These results were similar to those published on giant tiger prawns (8 days) and white-leg shrimps (9 days) [22, 25].

Verification results of QIM scheme for Jinga shrimps. Ten random shrimp samples with different freshness (unknown) were collected at Do Son port. The panelists scored them using the developed QIM scheme (Table 1). Table 3 shows the results of determining the storage time, predicting the remaining shelf life according to the equation (*), and the actual shelf life.

Table 3 shows no statistically significant difference between the predicted and actual storage dates. The residual value of the actual shelf life was close to the residual shelf life calculated using the regression equation (*). The obtained results indicate the possibility of estimating the preservation limit and predicting the remaining storage time of Jinga shrimp stored at 0–4°C. The result suggested that the QIM scheme developed for Jinga shrimp quality assessment provided good results and proved suitable for practical evaluation. It can be used as a reliable scientific tool to assess freshness and quality of raw Jinga shrimps.

Table 3 Determining the estimated shelf life according to the QIM program and the remaining actual shelf life of Jinga shrimps stored in ice water

Sample	Initial QI	Precalculated storage, days	Predicted remaining shelf life, days	Actual storage date based on observation, days
1	7.00	2.31	7.69	8.20 ± 0.45
2	9.00	4.03	5.97	6.40 ± 0.55
3	11.33	6.05	3.95	2.80 ± 0.84
4	12.33	6.91	3.09	3.60 ± 1.14
5	13.00	7.48	2.52	2.40 ± 0.89
6	14.67	8.92	1.08	1.20 ± 0.84
7	16.00	10.07	–0.07	–
8	17.33	11.22	–1.22	–
9	18.33	12.08	–2.08	–
10	19.67	13.23	–3.23	–

CONCLUSION

This study featured the transformations of Jinga shrimp sensory profile during storage in ice water. We developed a Quality Index Method (QIM) scheme to assess the sensory quality of Jinga shrimps based on nine sensory properties, with an Quality Index score of 0–26. We also developed a correlation equation between the QI score and the storage time with the coefficient of $R^2 = 0.97$. The best shelf life of Jinga shrimps stored in ice water was predicted to be between 8 and 10 days. The QIM program is a user-friendly and effective science-based tool that delivers fast and reliable results. It can help customers, fishermen, traders, aquaculture enterprises, and quality control officials to specify the storage time and estimate the remaining shelf life of Jinga shrimps. However, to improve the effectiveness and persuasiveness of the quality index method, it is possible to combine it with the chemical indicators of freshness, this creating a complete program for the Jinga shrimp quality assessment.

CONTRIBUTION

B.T.T. Hien: research concept, methodology, formal analysis, research, original draft, review and proofreading. D.T. Pham: methodology, research, and original draft. L.P. Vu: validation and research. P.H. Dao: validation and research. P.V. Tuyen: research. N.V. Nghia: research, review and proofreading. N.K. Bat: formal analysis, research, and original draft. All the authors have read and agreed to the published version of the manuscript.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interests regarding the publication if this article.

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