Sensory Assessment of Frozen Prawns

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Abstract

Sensory assessment is one of the inspection methods officially enforced on imported foods by USA and Canada. Though often said to be "subjective", an efficient assessment can be achieved through training. Sensory assessment is now recognised as an effective monitoring procedure to evaluate the quality of raw materials and in-process quality control in HACCP. The main purpose of this study is to define the sensory profile of black tiger prawn (Penaeus monodon) and banana prawn (Penaeus merguiensis), develop assessment techniques to be used by industry's laboratories and recommend suitable handling practice and storage time. In order to obtain samples of different quality levels, black tiger prawn and banana prawn were allowed to deteriorate at room temperature and on ice prior to processing into frozen products. Evaluation of sensory quality was performed by qualified prawn graders from USA and Canada. Chemical quality index "indole" was analysed on all samples. Training procedures and sensory profile of the products were developed. Thirty-one trained and qualified panelists, including inspectors from the Thai Department of Fisheries and quality control personnel from industry, participated in the sensory sessions. Storage time of not more than 32 hours at ambient temperature and 6 days on ice was recommended for black tiger prawn. Banana prawn should not be held for more than 12 hours at ambient temperature and 6 days on ice. The indole contents found in the rejected samples were way below the defect action level for prawn decomposition of 25 μg/100g suggested by USFDA. It is concluded that indole is not a good quality index for low temperature spoilage of prawn.

Introduction

Export of Thai frozen prawn amounted to US$ 6.9 billion or 450,278 tonnes in 1995. The marked expansion of black tiger prawn aquaculture since 1985 was the major contributory factor to Thailand becoming one of the world's largest frozen prawn exporters. Approximately 80% of the total export is cultured prawns. Wild catch decreased substantially due to over exploitation of natural resources. In addition, the quality of the catch is rather low due to poor handling practices and lengthy storage time onboard fishing vessels without proper icing. Major markets of Thai frozen prawns are USA and Japan. Although export to Canada amounted to 4% of Thailand's total exports, yet this accounted for 42% of Canada's market share.

Sensory assessment is officially enforced on imported food products by USA and Canada. Objective judgments can be achieved through extensive training especially by sensory experts of the import authorities. Sensory assessment is recognized as an effective monitoring procedure to evaluate quality of raw materials and in-process quality control in the Hazard Analysis and Critical Control Point (HACCP)-based program. Decomposition is a problem commonly found in low quality seafood products which results in rejection of the shipment. These characteristics can be directly perceived by way of sensory test. In order to confirm the initial sensory results, indole, a product of tryptophan degradation, is currently used by the US Food and Drug Administration (USFDA) to validate the sensory evaluation of prawn decomposition. Defect action level of 25 μg/100g is recommended.

The Department of Fisheries (DOF) of Thailand has invited 2 sensory experts from USA and Canada to train the Thai industry and DOF inspectors on sensory evaluation of frozen prawn. The samples used had been previously prepared under controlled spoilage. The purposes of this study were to define the sensory profile of frozen black tiger prawn (*Penaeus monodon*) and banana prawn (*Penaeus merguiensis*), develop assessment techniques and recommend suitable handling practices and proper storage time. All the samples used were also determined for indole contents so as to study correlations between sensory and chemical analyses.

Materials and Methods

The study was divided into 5 experiments depending on prawn species, storage conditions and final products as follows :

1. Experiment 1 : Black tiger prawn stored at ambient temperature - frozen raw prawn.

Live black tiger prawn, cultured in Satun Province, sized 36-40 count (per kg) were killed immediately after catch by plunging in iced water, and then drained. Twenty-five kg of prawn samples at 0 hour (right after death) were then drawn at this point, transferred into an insulated container and stored between ice layers. The rest were well iced in bigger insulated containers. All the samples were then transferred immediately by truck to a freezing plant in Had-Yai, Songkhla Province.

On arrival at the plant, the ice was removed but the prawn were left in the same containers. At intervals of 6, 9, 12, 16, 20, 27, 32 and 43 hours, samples were collected and processed into peeled headless tail-on and frozen in IQF (Individual Quick Frozen) form. The frozen prawn were packed in plastic bags, 200 g each, and stored at -18°C for 6 months prior to performing sensory and chemical analyses. These same conditions, viz IQF-peeled headless tail-on, packing size and storage time and temperature were used throughout the 5 experiments.

Though the room temperature during the study period was between 27-30°C, the prawn temperature was still as low as 10-20°C due to initial cooling effect of the ice. To hasten the spoilage and determine effects of temperature abuse, an additional sample was taken at 26 hours and immersed in tap water until the prawn temperature increased to 25°C, drained and maintained at room temperature for another 16 hours prior to processing, freezing and storage. This sample was called "TAS" (T=black tiger prawn, A=ambient, S=special).

2. Experiment 2 : Black tiger prawn stored in ice - frozen raw prawn.

Upon arrival of the iced prawn at the plant, the samples were transferred into insulated containers and packed in ice. The prawn were collected for further processing and storage at intervals of 0, 1, 3, 4, 6, 8 and 10 days.

3. Experiment 3 : Black tiger prawn stored at ambient temperature - frozen cooked prawn.

The prawn stored at ambient temperature for 0, 3, 6, 9, 20, 27, 32 and 43 hours as well as the raised temperature sample (TAS) were beheaded, peeled and cooked in boiling water for 3 minutes. The cooked prawn, TCS (T=black tiger prawn, C=cooked, S=specical), were immediately immersed in iced water prior to freezing and storage.

4. Experiment 4 : Banana prawn stored at ambient temperature - frozen raw prawn.

Banana prawn were caught from the Andaman Sea, stored in ice on board for 5 days prior to landing in Krabi Province. The prawn were transferred in ice to a freezing plant in the province by truck. The prawn (30-40 count per kg) were then sorted and packed without ice in insulated containers. Samples were drawn at 0 , 3, 9, 12, 15, 17 and 18.5 hours for further processing and storage. It should be noted that in experiments 4 and 5, the 0 hour sample was actually held 5 days in ice on board the fishing boat plus transportation time from the landing place to the plant.

5. Experiment 5 : Banana prawn stored in ice - frozen raw prawn.

Upon arrival at the plant, banana prawn were sorted and repacked in ice. At intervals of 0, 2, 4, 6 and 8 days, samples were removed for further processing and storage.

6. Sensory Assessment

The sample bags were immersed in room temperature water (20-25°C) for approximately 5 minutes. The thawed prawns were placed in a white-coloured plastic bowl for sensory examination by 2 experts and 31 participants. Samples were evaluated by product type. In the first session, samples were placed in order from best to lowest quality. The experts demonstrated sensory evaluation techniques and explained characteristics of acceptable, borderline and reject quality. Judgments were basically made based on odour of decomposition. The experts and participants subsequently drafted the sensory profile of frozen raw and cooked prawn using terms that corresponded well with sensory perception of all assessors. This profile was used to describe quality levels throughout the study. In the second session, samples were placed in random order and the participants examined the products and discussed their results with the experts. In the third session, which was a completely blind test, the experts and participants examined the products independently using their own opinions.

The assessors, comprising the sensory experts from the US and Canada and 31 Thai participants, indicated their judgment on quality of the samples by recording the "intensity" or

"degree" of the pass/fail decision by placing a vertical mark on the 10-centimeter line scale provided on the evaluation ballot. Positions from the extreme left end of the line to the midpoint indicate that the sample is of acceptable quality (A) whereas those to the right of the midpoint indicate that the sample has been rejected (R). As one moves from the left to the right of the line, the quality of the sample becomes worse. The midpoint of the line must not be used in this exercise. The 10-centimeter scale represents 100 marks, where 0 means best quality and 100 means worst quality. Marks between 45-55 excluding 50 (midpoint) represents borderline quality. A description of the odour, flavour, appearance and texture which resulted in the decision taken should also be written in the appropriate space in the "comment" column.

7. Chemical Analyses

The frozen prawn were thawed and analysed for indole contents. The levels of indole were determined by AOAC method (AOAC, 1990) using Liquid Chromatograph.

8. Statistical Analyses

Linear regressions were calculated to determine correlations between sensory scores and indole contents.

Results And Discussion

Sensory profile of frozen prawn (Table 1) was the result of discussion among the experts and participants. The descriptions of different quality levels were based on group consensus on characteristics perceived and should be understandable to all. The profile was used to determine quality of the frozen prawn throughout the study.

1. Experiment 1 : Black tiger prawn stored at ambient temperature - frozen raw prawn.

Fig. 1 shows the changes of sensory scores and indole contents of frozen raw peeled headless black tiger prawn of various quality levels whilst Table 2 shows sensory characteristics of the samples. Indole content of 0.3 µg /100g was found in the prawn immediately after harvest. The assessors described the sensory quality of good quality prawn as firm and resilient texture, bright, glossy appearance, and grassy or seaweedy odour. When storage time increased, deterioration began and the following characteristics were found: discolouration, soft texture, slimy surface, milky appearance, stale, sour, musty and putrid odour. The discolouration, red or orange off-colour development in shrimp, is due to denaturation of astaxanthin-protein complex and oxidation of red astaxanthin to orange astaxin and/or to the presence of a cryptaxanthin-like yellow pigment (Larry and Salwin, 1966). Cobb III *et al.* (1977) concluded that off-odour development in the shrimp appeared to be divided into two categories: (a) musty and cooked shrimp odours due to chemical and/or enzymatic activity and (b) putrid and sour odours due to bacterial activities. Cooked shrimp and musty odours occurred in some samples which had little increase in bacterial levels, while putrid shrimp odours occurred only in shrimp with high bacterial levels.

During 32 hours of storage at ambient temperature, there was no significant change in indole contents. The values were between 0.1-0.6 µg/100g. Indole markedly increased to 5.6 µg/100g when the raw material were stored for 43 hours. The special sample (TAS) which was kept at alleviated temperature, contained extremely high indole of 93.6 µg/100g. The total storage time of the sample was 42 hours which was very close to the 43-hour sample. This study confirmed the conclusion of Shamshad *et al.* (1990) that handling and storage at elevated temperatures had a profound effect on the quality of shrimp. They concluded that the increase in number of bacteria causing indole development was more rapid at higher temperatures, especially at 25°C, 30°C and 35°C when compared to 0°C and 5°C and correlated with the rapid decrease in sensory quality of the shrimp.

The prawn samples of 32 hours were borderline-acceptable although the indole content was as low as 0.4 µg/100g. The assessors borderline-failed the samples stored for 43 hours because they were discoloured, opaque, musty, slightly putrid and ammonical. The sample possessed 5.6 µg/100g indole. This was much lower than the actionable level of 25 µg/100g established by USFDA. Although this study was designed to store the raw material at ambient temperature, the fact of the matter was that the temperature of the sample was maintained between 10-20°C due to residual effects of previous icing.

The special sample (TAS) was unanimously failed by all assessors due to its cooked appearance, opaque meat and putrid odour. Alleviation of storage temperature has effectively increased indole level. Chang *et al.* (1983) concluded that while indole levels indicate decomposition, decomposed shrimp may not necessarily contain indole. Indole is of value in

assessing the history of shrimp if high temperature abuse is suspected. This is the reason why USFDA enforces sensory assessment as a principal method for seafood inspection. Confirmation by determining indole content is to be conducted if the product has been failed by the initial sensory test.

In this present study, it was found that sensory scores correlated very well with indole level, $r = 0.88$ ($P < 0.01$).

2. Experiment 2 : Black tiger prawn stored in ice - frozen raw prawn.

Prawn held on ice for 0-6 days prior to freezing contained approximately 0-0.4 µg/100g indole (Fig. 2). Quality of prawn stored for 6 days began to deteriorate since slight discolouration and milky appearance was present (Table 3). The assessors borderline-failed the prawns stored for 8 days though indole content was low as 1.7 µg/100g. When storage time of the raw material increased to 10 days, indole level drastically increased to 174.4 µg/100g or 100 times higher during the last 2 days of storage. The assessors unanimously rejected the samples due to soft texture, opacity, bleached colour, red discolouration and putrid odour. The significant change could be caused by substantial growth of indole-forming bacteria. *Proteus* was believed to be responsible for the formation of indole (Chang *et al.* 1983). Chang *et al.* (1983) also concluded that level of indole in frozen shrimp is an indicator of pre-freezing quality and not the result of a substantial increase during frozen storage.

Though the prawn sample containing 1.7 µg/100g indole which was much lower than the FDA actionable level was rejected by the assessors based on sensory quality, the correlation between sensory scores and indole contents was significant, $r = 0.85$ ($P < 0.05$). This was due to the fact that sensory scores increased with indole contents especially at the end of the storage.

3. Experiment 3 : Black tiger prawn stored at ambient temperature - frozen cooked prawn.

The sensory scores and indole levels and characteristics of frozen cooked black tiger prawn of which raw materials had been held at ambient temperature for 0, 3, 6, 9, 20, 27, 32, 43 hours and at alleviated temperature are shown in Fig. 3 and Table 4. The special raw material with raised temperature (TAS) when cooked prior to freezing was titled TCS. There was a slight change in indole content of raw material stored at ambient temperature for 32 hrs. The levels were somewhat stable between 0.2-0.7 µg/100g. The values significantly developed from 0.3 to 7.3 µg/100g between 32 and 43 hours of storage. The frozen cooked prawn sample produced from raw material stored at ambient temperature for 43 hours was of borderline- acceptable quality. The frozen raw prawn of the same storage condition was found borderline- failed. Thus, cooking should play an important role in removing some undesirable appearance, colour, odour, flavour and texture. It should be noticed that indole contents of the TAS (93.6 µg/100g) and TCS (47.2 µg/100g) were significantly different. Similar phenomenon has been reported by Chang *et al.* (1983) when shrimp samples containing 141 µg/100g indole lost approximately 60 µg/100g during a 5-minute boiling period. They concluded that the shrimp samples, *Penaeus setiferrus* and *Penaeus duorarum*, with < 25 µg/100g indole would not be altered during further processing. Higher indole levels may be reduced during boiling but would still be above the 25 µg/100g level.

In this experiment, sensory scores increased with time and indole content. There was a significant correlation ($r = 0.89$, $P < 0.01$) between sensory quality and indole level.

4. Experiment 4 : Banana prawn stored at ambient temperature - frozen raw prawn.

Fig. 4 and Table 5 show sensory scores and indole contents and characteristics of frozen banana prawn of which raw materials had been held at ambient temperature for 0, 3, 9, 12, 15, 17 and 18.5 hours. The 0-hour sample had actually been stored in ice on board a fishing boat for 5 days plus transportation time to the freezing plant. Hence, the initial indole was comparatively high at 8.7 µg/100g. However, the assessors still accepted the products though discolouration was found in some sample. This quality level of wild catch prawn is normally obtained due to long fishing trips made by small and medium-sized fishing boats. Prawn caught may remain on deck for several hours before icing. During handling on board, an inadequate quantity of ice is generally used.

During the first 12 hours of storage, indole contents fluctuated between 2.1-8.7 µg/100g. The assessors accepted the samples but found the 12-hour sample slightly stale in odour, slightly discoloured and not very good appearance. Freshness of cultured prawn is more controllable than that of wild catch. Cultured prawn are harvested and always iced immediately. This results in very low indole content developed in the samples. For banana prawn in this study, the prawn would have undergone temperature abuse or

held without proper icing during sorting and handling on board. The shelf life was therefore rather short compared to black tiger. Chang *et al.* (1983) concluded that mesophilic organisms commonly found had the ability to convert tryptophan in prawn to indole. Thus, indole formation indicates high temperature abuse. The experts from USA and Canada failed the sample of 15-hour storage though the majority of the participants still borderline-accepted the samples. The experts described the samples as discoloured, sour odour and soft texture.

It should be noticed that indole level drastically increased within a few hours from 14.1 to 48.1 μg/100g between 15 and 17 hours and from 48.1 to 81.4 μg/100g between 17 and 18.5 hours. This indicated a rapid growth of indole forming bacteria after 12 hours of storage at ambient temperature. In the present study, raw materials stored at room temperature for more than 12-15 hours should not be processed into frozen raw products since there was a good chance the products could be rejected due to decomposition.

The correlation coefficient (r value) of the samples was 0.93 ($P < 0.01$) which means that sensory scores significantly correlated with indole content.

5. Experiment 5 : Banana prawn stored in ice - frozen raw prawn.

Fig. 5 and Table 6 show the change in sensory quality and indole contents of frozen raw banana prawn of which raw materials had been stored in ice for 0-8 days. The initial quality of the raw material was not of prime quality and this was indicated by initial 8.7 μg/100g indole on day 0. Though the indole quality index fluctuated during storage, sensory scores gradually increased with time. The frozen prawn were rejected unanimously by the assessors after the raw material had been stored for 8 days. Banana prawns possessed stronger sour and fermented odour when decomposed compared to black tiger. This keeping time seemed rather short when compared to the studies of Fatima *et al.* (1981). Fatima *et al.* (1981) assessed the sensory quality of banana prawn stored in ice and concluded that it was of high- quality for 8 days and was acceptable up to 16 days. However, the raw material of their study was received from a short fishing trip of less than 10 hours and sensory evaluation was conducted on cooked prawn which had been boiled for 5 minutes. Cooking could have removed the undesirable flavour, odour, colour and moisture in the samples.

In this study, both black tiger and banana prawns stored in ice prior to freezing had keeping quality of approximately 6 days although the initial freshness of each species was somewhat different. Shelf life of the raw prawn stored at ambient temperature was significantly different. Black tiger prawn had keeping quality of up to 32 hours while banana prawn should not be stored for more than 12 hours. Temperature abuse is the primary factor affecting decomposition in prawn as indicated by sensory quality and indole content. Poor initial quality was largely responsible for rapid deterioration in the products.

In this study, the indole content fluctuated throughout storage period. On Day 8 the samples were failed by all assessors due to soft texture, no resilience, putrid and fermented odour and discolouration. The indole level remained as low as 10.5 μg/100g. Hence, there was no correlation ($r = 0.57$, $P < 0.5$) between sensory scores and indole content.

Conclusion

Sensory evaluation of seafood products is a reliable method to describe quality. This is the reason why the method is well-recognised and widely used in many major importing countries. Training inspectors to recognise odour and flavour of acceptable and decomposed levels is the way to support a complete inspection and quality control system. Indole, though enforced by FDA to confirm decomposition in prawn, is a good quality index for raw prawn which have undergone high temperature abuse. However, the index is of less value if the spoilage has occurred in ice or at low temperature. It can be concluded that while indole levels indicate decomposition, decomposed prawn may not contain indole.

From this study, black tiger prawn should not be left at room temperature for more than 32 hours prior to processing into frozen raw products. Cooking process was able to remove some undesirable odour and flavour and improve colour and texture in raw prawn. This resulted in slightly prolonged shelf life from 32 hours to 43 hours. However, the quality was at borderline level which could be rejected by inspectors of USA and Canada. Black tiger prawn stored in ice had a keeping time at this condition of around 6 days, and so did the banana prawn. Banana prawn should not be stored at ambient temperature for more than 12 hours. Initial quality of the banana prawn were much lower than that of black tiger prawn, as indicated by indole levels. Storage temperature and initial quality are the major factors affecting shelf life and quality of the final products. However, to achieve the best quality

products, raw materials should be kept at all times at low temperature, and strictly avoid any circumstances that may lead to temperature abuse.

In all experiments, sensory scores have shown good correlations with the formation of indole except in banana prawn stored in ice. The indole contents were somewhat consistent while the sensory scores increased with time. It should be concluded that indole is not a good quality index for deterioration of prawn at low temperature. Thus, sensory evaluation is still the most reliable method for quality control and from safety points of view. Characteristics of decomposed prawns of different species are somewhat different. Inspectors should be trained to recognise various spoilage characteristics of major species to ensure reliable judgment. Future studies should look at more varieties of spoilage patterns which imitate actual field practices, such as delay in icing on board fishing boat after catch, temperature fluctuation during landing, sorting or transportation.

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DISCUSSION

Ms Krissana stressed that the study was also designed to train Thai fish quality inspectors, that is why indole test was used as this is widely used in the U.S.A. There was no plan to use other index in the experiment. She clarified that poor quality shrimp samples were prepared by keeping them at room temperature for 32 hours.

Table 1. Sensory profiles of frozen prawn.

Quality level	Characteristics			
	Odour	Appearance	Texture	Colour
Passable	Fresh sweet, neutral, grassy-seaweedy	Translucent	Firm	Uniform, colour typical of species
Borderline to passable	Slightly stale, slightly yeasty, slightly fishy	Translucent	Slightly soft	Slightly discoloured
Borderline to fail	Musty, slightly sour, fishy, old sock odour	Slightly opaque, black spots	Tough, soft, dehydrated	Bleached or faded
Fail	Putrid, ammoniacal, faecal, chemical-fuel contaminants	Opaque, cooked appearance	Soft mushy	Discoloured

Table 2. Sensory characteristics of frozen raw balck tiger prawn of which raw materials had been stored at ambient temperature.

Storage period (h)	Characteristics
0	Firm, resilient, bright, glossy, grassy or seaweedy odour
6	Firm, resilient, uniform colour, fresh odour
9	Firm, slightly faded, slightly discoloured, fresh odour
12	Slightly soft, slightly slimy, slightly discoloured, slightly stale
16	Slightly opaque, slightly discoloured
20	Slightly discoloured, neutral odour
27	Firm, slightly discoloured, slightly stale
32	Not resilient, discoloured, opaque, musty, slightly putrid, slightly ammoniacal
43	Not resilient, discoloured, opaque, musty, slightly putrid, slightly ammoniacal
TAS*	Orange discoloured, opaque, strong putrid

*T=black tiger prawn, A=ambient temperature, S=special

Table 3. Sensory characteristics of frozen raw black tiger prawn of which raw materials had been stored in ice.

Storage period (days)	Characteristics
0	Firm, resilient, bright, and uniform colour, fresh sweet odour
1	Firm, resilient, slightly discoloured and sweet odour
3	Firm, slightly discoloured, slightly stale
4	Opaque, bleached, slightly discoloured, neutral odour
6	Slightly discoloured, milky appearance
8	Opaque, slightly discoloured, musty, slightly putrid
10	Soft, opaque, bleached, red discoloured, strong putrid

Table 4. Sensory characteristics of frozen, cooled black tiger prawn of which raw materials had been stored at ambient temperature.

Storage period (h)	Characteristics
0	Bright, uniform, fresh and sweet odour
3	Bright, uniform, fresh and sweet odour, slightly cold storage odour
6	Neutral odour
9	Slightly opaque, slightly stale, slightly musty
20	Opaque, slightly stale
27	Some translucent, some opaque, bleached, slightly stale
32	Slightly stale, slightly musty
43	Discoloured, stale, old odour, slightly musty
TCS*	Opaque, strong putrid and hydrogen sulphide odour

*T=black tiger prawn, C=cooked, S=special

Table 5. Sensory characteristics of frozen raw banana prawn of which raw materials had been stored at ambient temperature.

Storage period (h)	Characteristics
0	Firm, slightly discoloured, neutral odour
3	Firm, not uniform quality, neutral odour
9	Firm, not uniform quality, slightly stale
12	Slightly discoloured, slightly stale, not good appearance
15	Soft, discoloured, stale and sour odour
17	Discoloured, putrid, ammoniacal odour
18.5	Discoloured, strong putrid odour

Table 6. Sensory characteristics of frozen, raw banana prawn of which raw materials had been stored in ice.

Storage period (days)	Characteristics
0	Firm, slightly discoloured, neutral odour
2	Discoloured, naturally sweet odour
4	Milky colour, typical odour
6	Discoloured, slightly stale
8	Soft, discoloured, not resilient, putrid and fermented odour

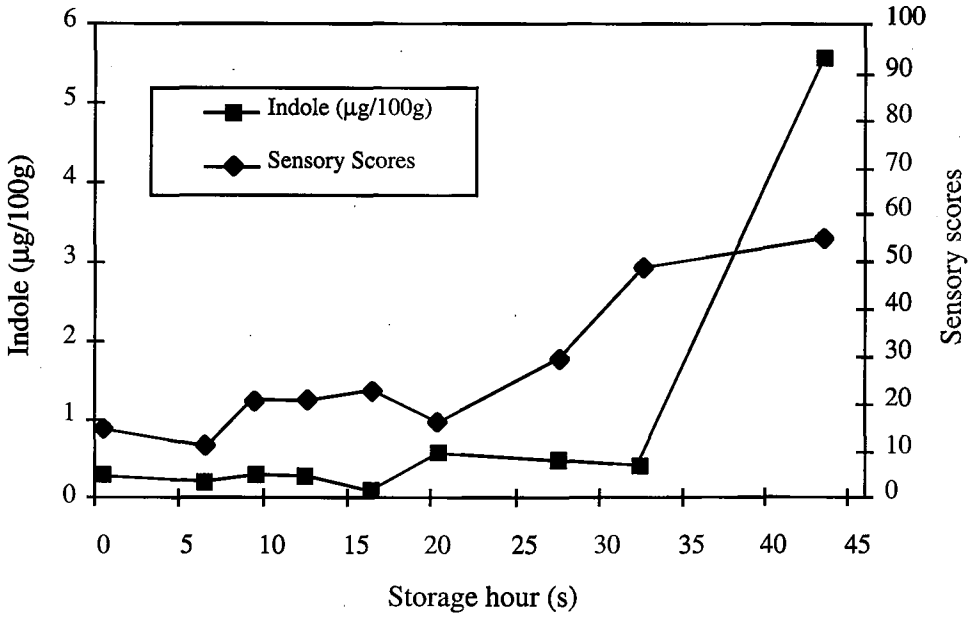

Fig. 1. Indole content and sensory score of frozen raw black tiger prawns of which raw materials had been stored at ambient temperature.

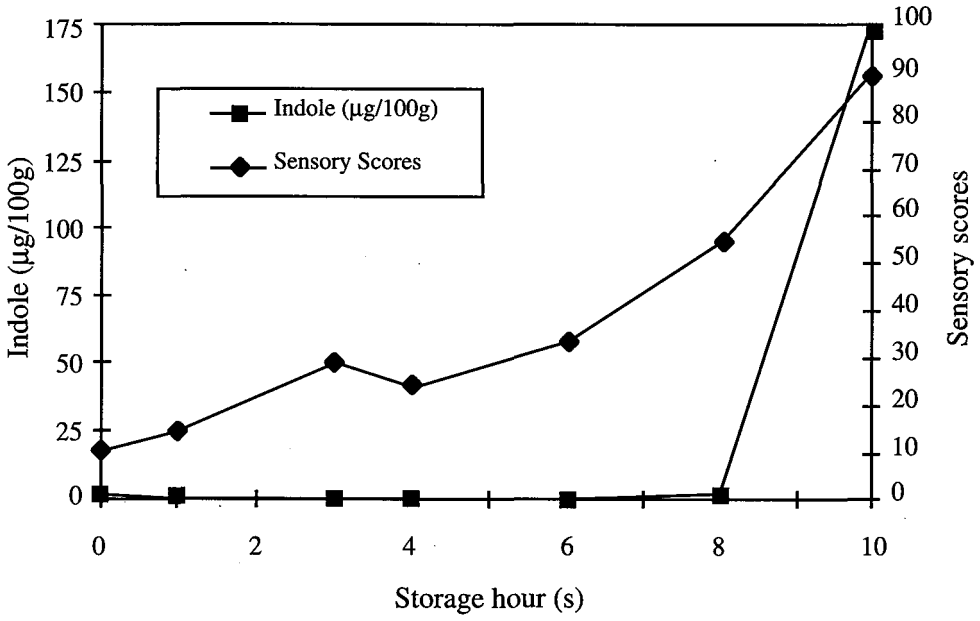

Fig. 2. Indole content and sensory score of frozen raw black tiger prawns of which raw materials had been stored in ice.

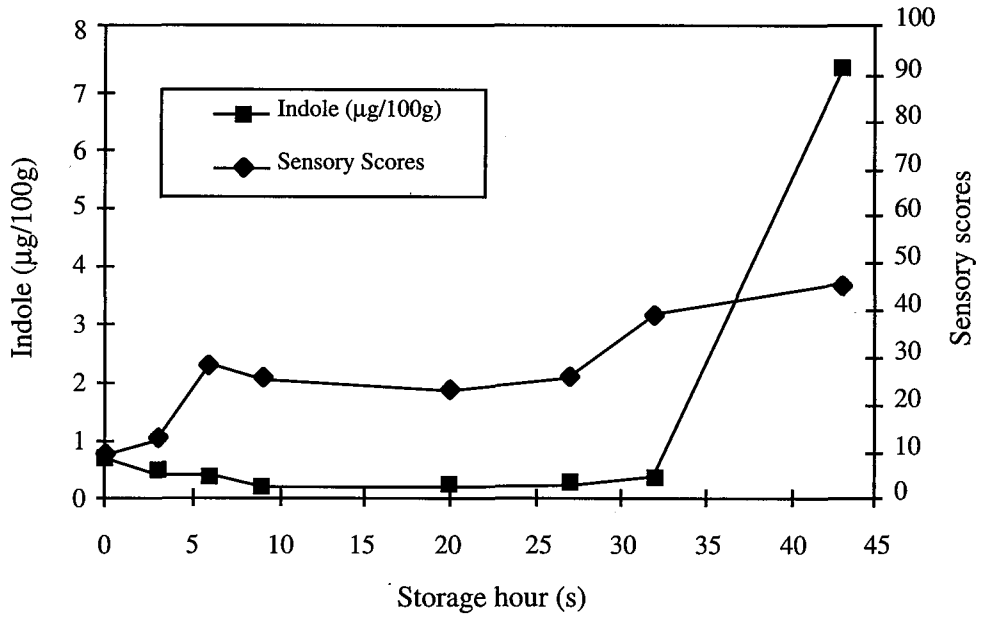

Fig. 3. Indole content and sensory score of frozen cooked black tiger prawns of which raw materials had been stored at ambient temperature.

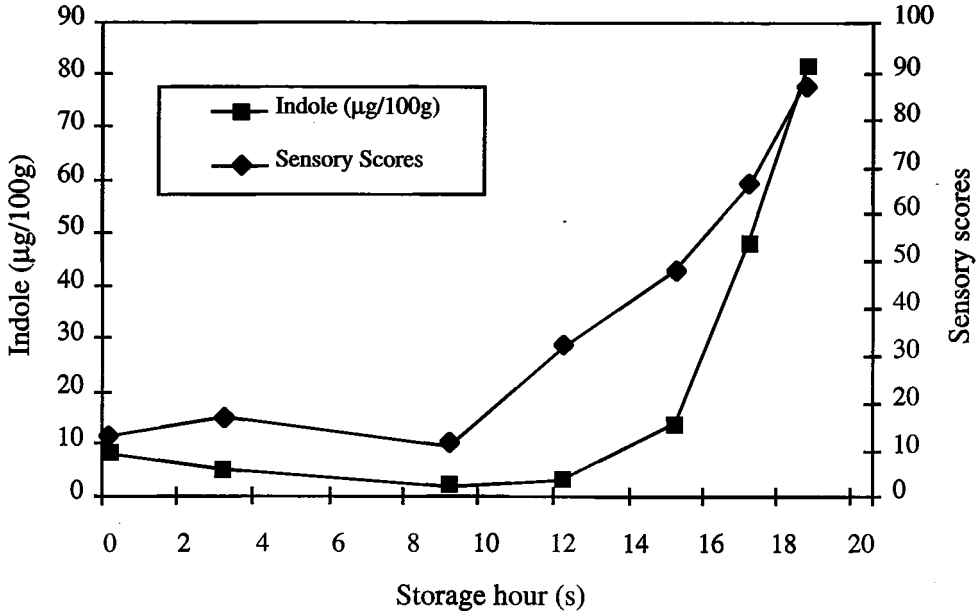

Fig. 4. Indole content and sensory score of frozen raw banana prawns of which raw materials had been stored at ambient temperature.

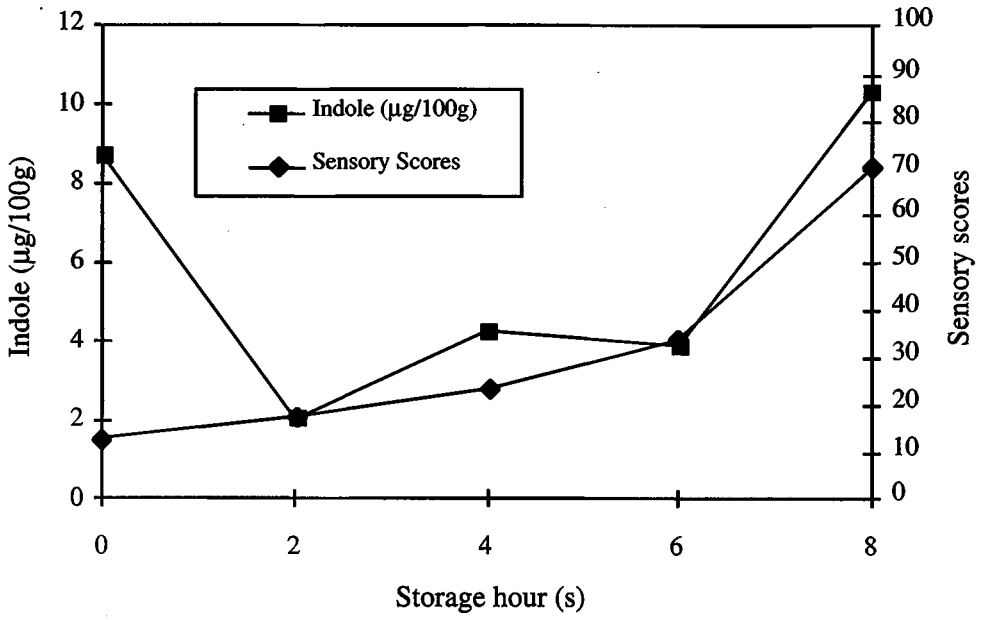

Fig. 5. Indole content and sensory score of frozen raw banana prawns of which raw materials had been stored in ice.