Storage Lives Of Chilled And Frozen Scampi

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Introduction

Scampi are a highly prized seafood and the discovery of a potential resource off the north-west shelf of Australia by CSIRO (Anon,1983) was greeted with excitement by the industry. Further research on the extent of the grounds by CSIRO was supported by the Fishing Industry Research Committee and this provided the unique opportunity to do post-harvest research on a fishery before it was fully commercially exploited.

The north-west shelf area of Australia lies between 10° and 20° south of the equator and is hot and remote with a coastal region that is sparsely populated and which has no processing infrastructure. Unlike the European fishery for *Nephrops norvegicus*, where the scampi are trawled or trapped inshore in shallow waters and may arrive live at the processors, the Australian resource is found in deeper offshore waters and is trawled for at depths of 200 to 500 metres or more (Davis and Ward, 1984). As a result they are landed dead and warm, having travelled slowly up through the hot surface waters. It is industry practice to sort, clean and freeze the scampi as soon as practical. The tails are removed from any damaged scampi and also frozen in separate packs. The trade is thus in frozen packs of whole scampi or scampi tails. Therefore it was important to determine whether significant changes occurred during frozen storage and on subsequent chilled storage after thawing.

This paper summarises work reported in detail previously (Bremner 1988a, 1988b) in which three species of scampi (*Metanephrops andamanicus, M. australiensis and M. boschmai)* were held frozen for up to 12 months and were evaluated in subsequent chilled storage after thawing. Results of chilled storage trials on *M. andamanicus* (Bremner, 1985) are also included.

Approach

Experiments that evaluate the changes that occur to fish stored in ice are a recognised baseline in seafood technology research and, as in all storage experiments, the initial results are critical in determining the inherent properties of the species and in providing the basis for measuring both absolute changes and rates of change. Logistics prevented this approach on all but one of the scampi species since they are caught on different grounds some days steaming apart (Davis and Ward, 1984) and the distance from the laboratory (3000 km) meant that four days elapsed before they could be evaluated.

The scampi were evaluated at all stages of the experiments by visual inspection, microbiology, nucleotide changes, chemical analysis and by sensory evaluation of the cooked flesh both hot and cold.

Materials And Experimental Outline

A full description of the materials, experimental outline and sensory techniques has been given previously (Bremner, 1985, 1988a,b) and only a brief outline will be included here.

The scampi were caught off the north-west shelf of Australia during February 1984 by the FRV *Soela* using a modified Engel prawn trawl. After sorting, measuring and weighing, they were hand-washed and both whole animals and tails, which had been removed by hand, were frozen on board in a blast freezer to a temperature near -30°C. They were transferred to a holding freezer (-20°C)

until the ship berthed in Hobart six weeks later, when the boxes were transferred to the storage freezer (-18°C). Whole *M. andamanicus* from the last haul on the return to port were packed in ice and air freighted to Hobart.

Analytical Methods

Protein, moisture, fat, and ash (AOAC methods), glycogen and saline extractable protein (SEP) were estimated. Nucleotides were determined on neutralized $HClO_4$ extracts of 10 g of flesh by HPLC using paired ion chromatography to separate homarine from the nucleotide peaks. Bacterial estimations were made on tryptone soy yeast agar using saline extracts of 10g scampi flesh and Gram-negative isolates were identified.

Sensory Methods

Visual inspection was done according to a demerit point scheme developed in the laboratory. Scampi cooked in boiling water were served hot to the taste panel. Odour and flavour profiling was done by the free choice method where panellists could score for a large variety of descriptive terms on a scale ranging from 0(absent) to 9(strong). In addition, it was compulsory for tasters to score for the attributes of typical odour, off-odour, typical flavour and off-flavour on 0-9 scales and also for the acceptability of odour, flavour and overall acceptability on the 1-7 hedonic 'Smiley' facial scale (Street and Carroll, 1972). Textural properties were also assessed using a 1-9 scale ranging from very wet(1) to very dry(9), very soft(1) to very firm(9), not springy(1) to very springy(9), very tender(1) to very tough(9), reduces water in the mouth(1) to increases water in the mouth(9), and not fibrous(1) to very definite fibres(9). All the tasters were very experienced at tasting seafoods by this profiling method; however two round table familiarisation sessions were held before the start of the experiment.

An acceptability panel also evaluated chilled cooked scampi served on lettuce for flavour, texture and overall acceptability on the seven point 'Smiley' scale.

Ice Storage Of *M. andamanicus*

Immediately after catch the scampi were washed and placed in ice. They were sampled 4, 7, 11, 13 and 17 days after catch and evaluated by pH measurement, microbiological count, visual assessment and by profile and acceptability panels.

Frozen Storage Trials

The scampi were evaluated after 2, 6 and 12 months storage (-18°C) using visual assessment, pH measurement, nucleotides and profile and acceptability panels.

Chill Storage Of Thawed Scampi

Scampi which had been frozen for 2 months were thawed at 8, 4 and 0 day intervals before assessment by pH, nucleotide and microbial measurement and by profile and acceptability panels.

Results

Ice Storage Of *M. andamanicus*

There was continued deteriorative change in appearance over the time of storage (Table 1) with an increase in flesh pH (Fig. 1) and an increase in total plate counts at 27°C from about 3×10^3 colony forming units (CFU)/g for the initial samples taken when first caught (on board) to 10^6 after 7 days up to 5×10^6 after 17 days. Spreading organisms made counts erratic but 60% of the initial isolates were *Bacillus* spp. and about 25% were *Moraxella* spp. There was no growth at 4°C in the initial samples, indicating absence of psychrotrophes.

The taste panel recorded increases in off-odours and off-flavours and concomitant decreases in typical odours and flavours along with a marked decrease in acceptability (Table 2). Unpleasant odours such as acrid, mousey, ammonia and sulphide were detected and flavour notes such as rubber, blood, greasy, soapy and astringent were reported (Table 2).

The overall results indicate that although there are considerable changes in appearance in

Table 1. Appearance and odour of *M. andamanicus* stored in ice.

Time of storage (days)	Appearance	Odour
0	Bright colour, clear eyes.	Only slight amount of fresh sea odour.
4	Blackish green head, eyes opaque, dark patches where legs join body, soft inside head, soft meat on butt of tail.	Fresh seaweed, freshfish.
7	Yellow green patches on carapace, black patches on uropods, very dark in gill area, digestive gland intact but soft.	Fishy, seafoody, but no off odours.
11	Continued darkening and yellow stains on shell, yellow fluid in head area, brown gills.	Very little odour.
13	Black patches over whole of carapace more noticeable in moulting animals, eyes clouded and loose on their stalks, some tails very loose, dull general appearance.	Astringent, antiseptic, oyster like, sour odours in heads.
17	Eggs of berried females loose and bleached in colour, legs easily shed.	Antiseptic (iodine), strong sulphide, stale old smell when tailed, ammoniacal, old drains, dog faeces.

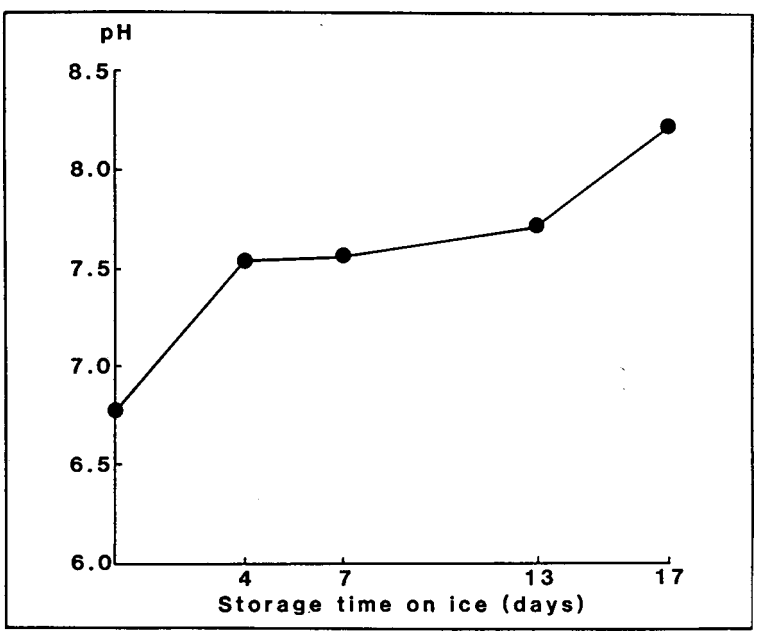


Fig. 1. pH of tail flesh of M. andamanicus *stored in ice.*

Table 2. Odour and flavour profiles of *M. andamanicus* stored in ice.

	Days post-catch stored in ice			
	4	7	13	17
Odour				
• Typical odour	5.5	4.5	2.8	2.6
• Off odour	0.5	0.8	2.5	3.2
Seaweedy	2.4	3.0	3.0	3.0
Shellfish	3.6	4.4	3.2	3.3
Boiled clothes	-	3.0	3.0	3.5
Wet straw	2.0	1.8	2.8	3.0
Mousey	-	-	2.0	4.0
Grassy	-	-	-	2.5
Sulphide	1.0	-	-	4.0
Ammonia	-	1.0	2.0	2.5
Acrid	-	1.0	1.3	2.0
•+ Odour acceptability	4.7	4.8	2.8	2.7
Flavour				
• Typical flavour	4.4	5.0	2.8	2.1
• Off flavour	0	0.3	1.4	4.0
Sweet	4.6	4.6	3.1	2.9
Salty	3.0	2.9	1.3	1.3
Butter	1.5	-	2.5	3.7
Carrots	3.2	2.2	3.0	2.0
Astringent	1.0	2.0	2.5	3.0
Soapy	-	-	2.5	2.5
Greasy	-	-	4	3
Creamy	3.2	2.8	2.0	2.0
Sulphide	-	-	-	4.0
Rubber	-	2.0	2.0	3.0
Blood	2.0	2.0	4.0	2.3
•+ Flavour acceptability	5.6	5.3	3.7	2.7
•+ Overall accaptability	5.5	5.2	4.3	3.0

• Mandatory score

\+ 7-point Smiley scale

this species within four days storage in ice they are mostly external and the flesh is little affected. Substantial change in the sensory properties does not occur until after seven days storage in ice.

Frozen Storage Trials

Appearance

On arrival at the laboratory the frozen scampi were perfect in appearance. After six months frozen storage slight purple patches were found on the carapace of *M. andamanicus* and yellow discolouration on both sides of the head of *M. boschmai* some of which also showed slight staining of the flesh. No off-odours were detected and the flesh smelt clean and fresh. After 12 months frozen storage the carapace colour in all three species had faded as had the colour of the eggs of berried females. The fading is most likely oxidative in nature and could be prevented by glazing or impermeable wrapping or treatment with sulphite or other approved antioxidant.

SEP And Nucleotides

Over the 12-month storage period the SEP decreased only slightly for all three species from near 83 g/100g protein to 72 g/100g protein indicating that the scampi proteins are remarkably stable in frozen storage. The total nucleotide pool was stable for the first six months but deteriorated by about 10% after 12 months storage. There was a steady increase in K-value from near 15% after two months to 40% after 12 months (Fig. 2).

Profile Panels

The off odour and off flavour scores for *M. andamanicus* and *M. boschmai* increased slightly but consistently with time of storage, with corresponding decreases in typical odour, flavour and overall acceptability.

The results for the free choice panels on scampi stored 2 months are reported as bar graphs for those attributes which panellists found important, with the data for the stored material shown at

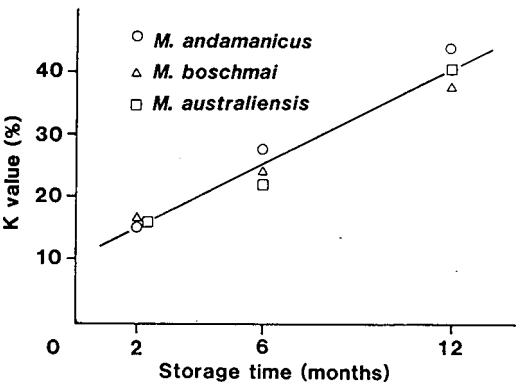


Fig. 2. Increase in K-value with period of frozen storage. A change in K-value of 8% is significant at the P≤0.001 level.

the right as differences in these profiles (Fig. 3). The development of undesirable odour and flavour characteristics and the decrease in desirable attributes is obvious.

Acceptability Panel

There were no percieved differences in acceptability between the species (Table 3). The samples stored for 12 months had significantly less flavour ($P \leq 0.01$), poorer texture ($P \leq 0.001$) and were less acceptable overall ($P \leq 0.05$) than those stored for only 2 or 6 months.

Chilled Storage Of Thawed Scampi

There was progressive deterioration of all three species in chilled storage similar to that reported in Table 1 for *M. andamanicus* and the pH increased for both whole scampi and for tails (Fig. 4). The total nucleotide pool slowly decreased and K-value increased (Fig. 5).

Few bacteria were detected on the thawed scampi, generally less than 100 cfu/g. Bacterial growth was slow, scarcely reaching 10^6 cfu/g after 8 days at 4°C. The main organism present was *A. putrefaciens,* with *Moraxella* spp. or coryneforms being the other major components of the flora.

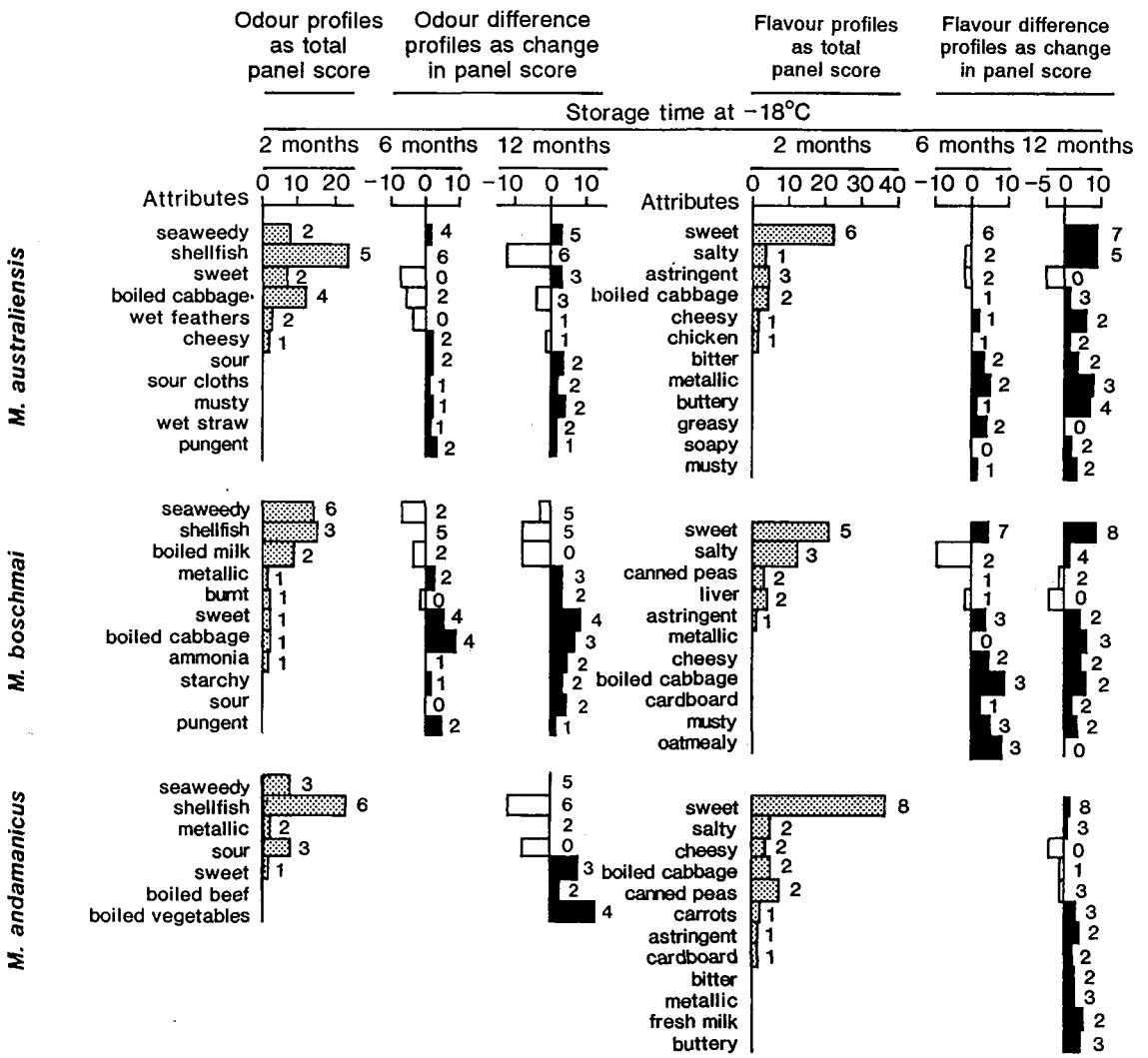


Fig. 3. Free choice odour and flavour profiles as total panel scores for 3 species of scampi frozen stored at −18°C for 2 months (shaded), and odour and flavour difference profiles showing changes in the attributes as ☐ *decrease and* ■ *increase or developing attributes for whole scampi stored at −18°C for 6 and 12 months. Numbers at right of each bar report the number of panelists contributing to the total panel score. Total possible score 90 (9 tasters X 10 point scale).*

Table 3. Scores for acceptability of frozen stored whole scampi boiled and served cold.

	Storage time (months)		
	2	6	12
Flavour acceptability			
M. andamanicus	5.47[a]	5.69[a]	4.52[b]
M. boschmai	5.47[a]	5.48[a]	5.07[b]
M. australiensis	5.44[a]	-	5.07[b]
Texture acceptability			
M. andamanicus	5.15[a]	5.44[a]	3.96[b]
M. boschmai	5.09[a]	5.33[a]	4.52[b]
M. australiensis	5.29[a]	-	4.46[b]
Overall acceptability			
M. andamanicus	5.33[a]	5.42[a]	4.31[b]
M. boschmai	5.27[a]	5.37[a]	4.92[b]
M. australiensis	5.30[a]	-	4.75[b]

Values differing signficantly ($P \leq 0.05$) across the table are marked by different superscripts. Least significant differences calculated from analysis of variance are 0.40 for flavour, 0.54 for texture and 0.51 for overall acceptability.

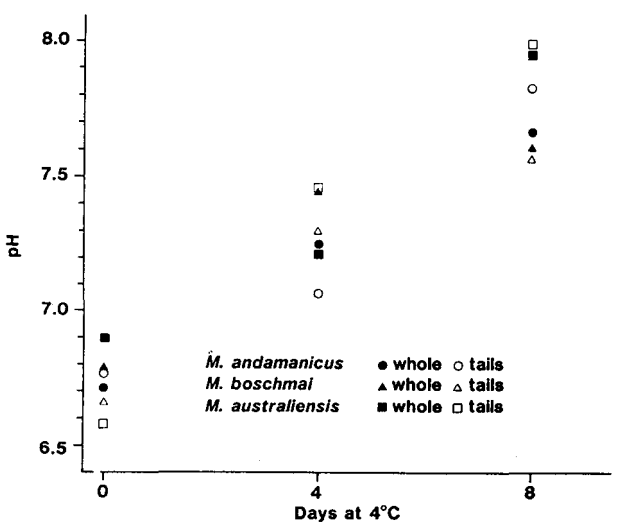
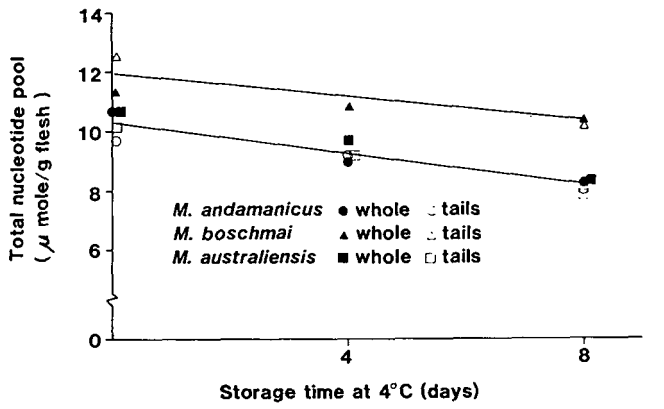


Fig. 4. pH of chill-stored scampi and scampi tails.



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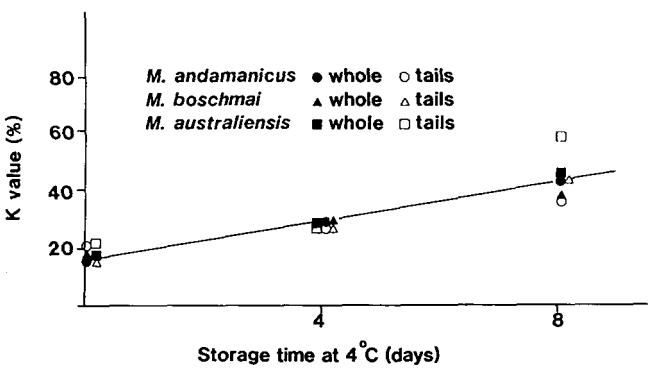

B

Fig. 5. (A) Change in total nucleotide pool for scampi at 4°C after thawing. Difference of 0.6 μmole are significant at the P≤0.05 level, both between species and with storage time. (B) K-value for scampi stored at 4°C after thawing. A change in K-value of 5.8% is significant at the P≤0.05 level.

Free Choice Profiles

There were considerable changes in the odour profiles during 8 days chilled storage particularly in *M. andamanicus* (Fig. 6) where odours described as ammonia, sour cloths, dirty socks, and wet feathers were reported. Similar changes (not shown here) were found in flavour profiles particularly with *M. australiensis* where undesirable attributes such as metallic, astringent, sour, liver and cardboard were reported. Similar deteriorative changes were also shown in the panel scores for the compulsory variates (Table 4).

Storage as tails resulted in fewer textural changes than occurred in the whole animals (Fig. 7) which generally softened, presumably due to the action of enzymes from the digestive gland.

Acceptability Panel

The three species were rated similarly and generally the scores given to the tails stored for 8 days (4°C) were not significantly lower than the initial scores. Storage in the whole form resulted in significant deterioration although some anomalies

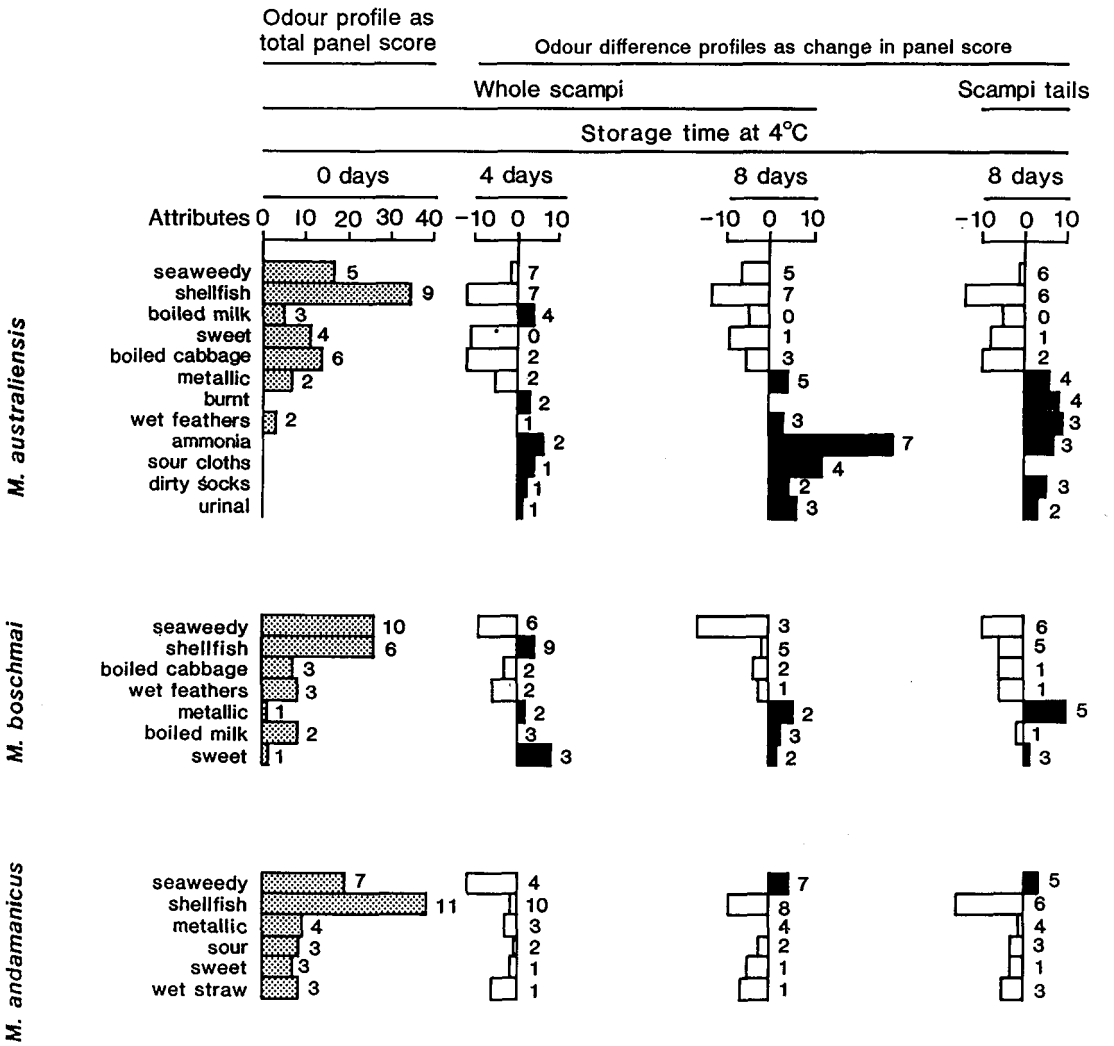

Fig. 6. Free choice odour profiles for three species of whole scampi freshly thawed (shaded), showing the main inherent attributes as total panel score and odour difference profiles showing changes in these attributes as □ decrease and ■ increase or developing attributes for whole scampi stored at 4°C for 4 and 8 days and scampi tails stored at 4°C for 8 days. Numbers at right of each bar report the number of panelists contributing to the total panel score. Total possible score 150 (15 tasters X 10 point scale).

occurred. It is obvious that scampi tails are the more stable in chilled storage.

Despite the obvious changes that occurred all the samples were acceptable to the panel even after 8 days storage at 4°C.

Flesh with levels of *Alteromonas putrefaciens* as high as these samples stored for 8 days (approx 10^6cfu/g) would normally be considered to be spoilt, yet the taste tests did not indicate this. It is likely that the *Alteromonas*

Table 4. Profile panel mean scores for those attributes it was compulsory to score.

	Storage time at 4°C (days)				
	Whole scampi			Tails	Trend with storage time
	0	4	8	8	
M. andamanicus					
Off odour	0.69[a]	1.38[b]	2.94[c]	2.63[c]	Increase
Off flavour	0.38	1.31	1.31	0.94	Increase
Typical odour	4.63	3.88	3.81	3.38	Decrease
Odour acceptability	4.69[a]	4.06[b]	2.74[c]	3.31[c]	Decrease
Typical flavour	5.25[a]	4.12[b]	3.64[b]	4.15[b]	Decrease
Flavour acceptability	4.94[a]	3.50[b]	3.75[b]	4.50[a]	Decrease
Overall acceptability	5.06[a]	3.38[c]	3.35[c]	4.50[b]	Decrease
M. boschmai					
Off odour	2.15[ab]	1.83[a]	2.51[b]	3.11[b]	Increase
Off flavour	0.91	0.59	1.46	1.11	Slight increase
Typical odour	3.71	4.55	3.16	3.37	Decrease
Odour acceptability	4.13[b]	4.60[a]	3.50[c]	3.26[c]	Decrease
Typical flavour	5.14[a]	5.01[a]	4.65[a]	5.15[a]	Slight decrease
Flavour acceptability	4.73[a]	4.69[a]	4.29[a]	4.01[b]	Slight decrease
Overall acceptability	4.40[a]	4.72[a]	4.23[a]	4.26[a]	Decrease
M. australiensis					
Off odour	0.58[a]	1.81[b]	1.75[b]	1.55[b]	Increase
Off flavour	0.35	0.88	0.88	1.56	Increase
Typical odour	5.13	4.69	5.31	4.56	No change
Odour acceptability	4.69[a]	4.00[b]	4.19[b]	3.81[b]	Decrease
Typical flavour	5.56[a]	4.56[b]	4.75[b]	4.69[b]	Decrease
Flavour acceptability	5.25[a]	4.35[bc]	4.69[b]	4.06[c]	Decrease
Overall acceptability	4.63[ab]	3.94[C]	5.00[a]	4.50[b]	Decrease

Values differing significantly ($P \leq 0.05$) (estimated by analysis of variance) across the table are marked by superscripts a, b or c.

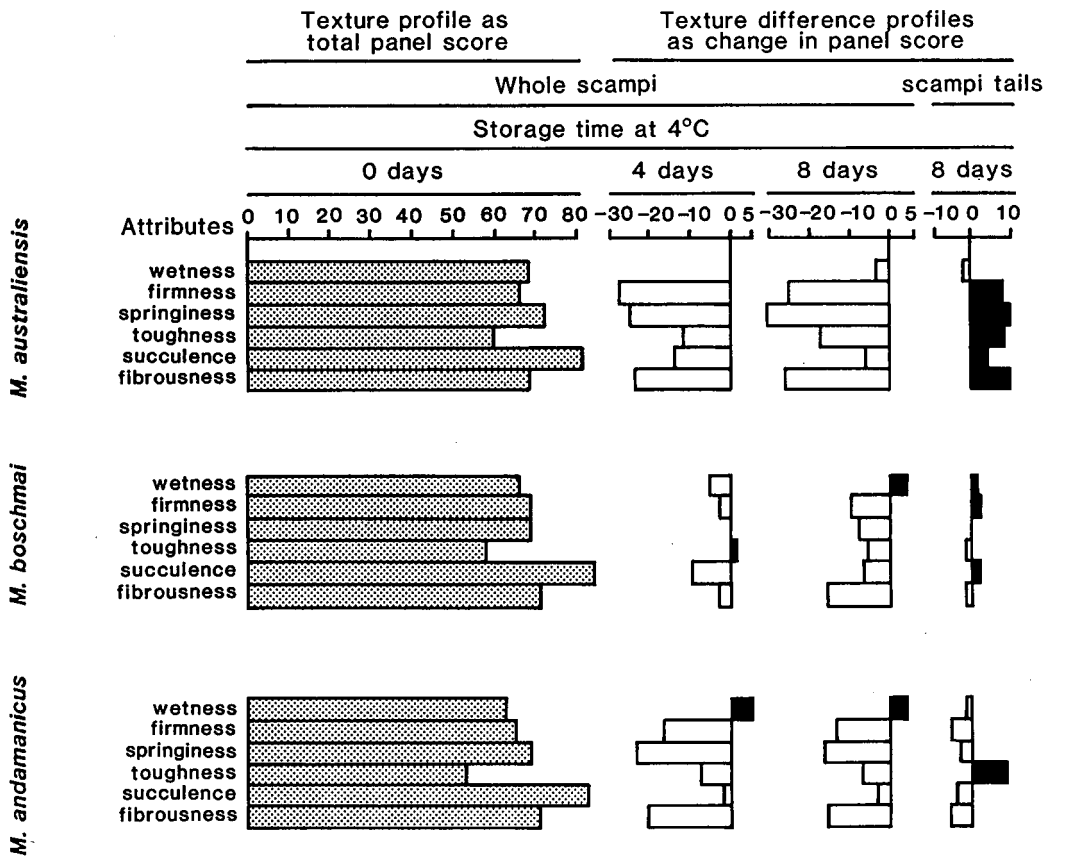

Fig. 7. Texture profiles for three species of whole scampi as total panel scores for freshly thawed (shaded) and texture difference profiles showing changes in these attributes as ☐ *decrease and* ■ *increase, for whole scampi stored at 4°C for 4 days and 8 days and scampi tails stored at 4°C for 8 days. Total possible score 135 (15 tasters X 9 point scale).*

utilised the carbohydrate present to meet its growth needs and hence fewer undesirable off-odours and off-flavours were produced than if it were utilizing free amino acids.

The strong positive character of the inherent scampi flavour, the stable sweet-salty flavours and the high IMP and low Hx levels were sufficient to maintain acceptability. This agrees with results calculated from a predictive equation linking acceptability positively to IMP levels and negatively to Hx levels (Fletcher *et al.*, 1990).

Conclusions Of The Experimental Work

Scampi stored in ice deteriorates in appearance turning blackish green at the head with gradually increasing yellow-green stains on the carapace and darkening black patches but is quite acceptable even after 7 days and just acceptable

after 17 days. They are quite stable in frozen storage with the superficial external changes having little effect on the flesh and only some slight decreases in acceptability and in sensory attributes after 12 months storage (-18°C) were noted.

In chilled storage nucleotide breakdown is slow and sufficient IMP to enhance the flavour remains even after 8 days at 4°C. While there is no difference between storage in the form of tails or as whole scampi in changes in pH, the bacterial count and composition, or to the rate of nucleotide breakdown the texture of the tails does not deteriorate whereas that of the whole scampi changes markedly.

The Current State Of The Fishery And Extension Of This Work To Industry

This work was done at the outset of the fishery and the results of the ice storage trial and preliminary results from the chill storage trial were communicated to the industry via the journal 'Australian Fisheries' (Bremner,1985) and through personal contact. There was considerable optimism in the industry for the future of this fishery, but it became apparent that the resource was limited and the remotenes made it an expensive fishery in which to operate. This situation has not changed and the fishery has stabilised at just under 100 mt per annum. In fact scampi tend to be more of an incidental catch of the deepwater prawn fishery on the NW shelf. The catch is cleaned and frozen on board in cartons containing 3 kg of whole scampi, or near 12 kg if tails only are packed. There is a ready market for the highest grade material in Japan where it fetches A$22/kg and on the US east coast where graded tails can bring near US$14/lb (A$40/kg.). The publicity about scampi in Australia generated a local demand which has been met by the importation of scampi from Scandinavia.

No technological problems with the Australian product have been encountered and further work has not been necessary, although this extensive set of experiments have provided a solid groundwork had it been required. The experimental design provides a model for comparable experimentation on other species under other circumstances. The features of the design were the extensive evaluation by free choice profile, combined with systematic visual appraisal, nucleotide analysis and microbiological investigation. In this way a composite picture of the properties of the flesh of the three species was built up which was useful for recommending storage and handling practices and for diagnosing potential problems which may arise in the future.

Acknowledgement

The author acknowledges the skilled assistance of Maria Ottenschlaeger with the taste panel work, Peter Kearney with the analyses, Dr. Jo Statham with the microbiology and Dr. D.A. Ratkowsky with the statistical analyses. The assistance of the CSIRO Division of Fisheries was greatly appreciated and the work was supported by grant 83/46 from the Australian Fishing Industry Research Committee.

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Discussion

Mr Bremner informed the meeting that a study had not been designed to compare the storage performance of prawns caught together with scampi, with that of scampi on board, but to investigate scampi only. However, there was a need for similar work to be done on the many species of prawns.

Mr Bremner also explained that the melanosis in scampi was enzymic and caused by the tyrosinase enzyme acting on tyrosine in the cuticle. As is done with prawns, scampi could be dipped in sodium metabisulphite to prevent melanosis. He added that changes in haemocyanin in blood was due to the presence of copper.